5. EXISTING CONDITIONS

This section is a general overview of conditions of Millers Creek and its watershed. Descriptions of individual reaches (sections of the stream) are also summarized in this chapter. Detailed descriptions of individual reaches within the creek, along with detailed site maps and photographs can be found in **Appendix D**. All the mapping data, in ArcMap format, can be found in **Appendix E**. A map of the reaches is shown in **Figure 5.1**. Each reach is referred to by the sampling station name at the downstream end of that reach. For example, the Plymouth reach ends at the Plymouth sampling station and includes all channel upstream of this sampling station. The Baxter reach begins at the Plymouth sampling station and ends at the Baxter sampling station. In some areas, the reaches are broken up into sub-reaches due to the heterogeneity of conditions within that reach.

5.1 General conditions

Climate

In Ann Arbor on average, 32-35 inches of total annual precipitation falls during roughly 120 days of the year (UM weather station data, **See Appendix F**). Over half the days with precipitation, the total precipitation amounts to 0.1 inches or less. On any given year, 90% of all daily precipitation events result in a 24-hour total depth of 0.66 inches or less. It is also highly probable in any given year that there are only 3 or 5 events with a 24-hour total of an inch or more of precipitation.

During January, typically the coldest month of the year, temperatures average between 16 and 30 degrees Fahrenheit (°F). During July, typically the warmest month of the year, temperatures average between 62 and 83 °F (NOAA, 2000). Average annual evaporation is nearly in balance with total precipitation, with approximately 31-33 inches a year lost to the atmosphere as evaporation (Eichenlaub, et al., 1990).

Geography

The Millers Creek watershed is located on the Defiance end moraine. The creek originates at an elevation of approximately 880 feet Mean Sea Level (MSL) and drops roughly 130 feet in 2.5 miles to an elevation of 746 MSL. The average gradient (elevation drop over length) of Millers Creek is approximately 52 ft/mi (See **Figure 5.2**). By comparison the Huron River from its headwaters to Lake Erie has an average gradient of 2.95 ft/mi. The Millers Creek gradient is rare in Southeast Michigan and theoretically should offer some of the area's most diverse stream habitat.

The creek flows across the broad Huron River valley, carrying some glacial outwash material, post-glacial alluvium and watershed soils. In the Ruthven Nature Area, a well-preserved kame marks the spot where granular material filled a glacial hole before the last retreat of the glaciers. When the glacier melted away, the granular material filling the void was left behind as a mound some 30 feet higher than the surrounding landscape.

Most of the soil in the watershed is classified as poorly draining (hydrologic soil class C) clay loam (See **Table 5.1** below). Some granular alluvium soils (material deposited historically by running water) are immediately adjacent to the creek, but they make up a small percentage of the total watershed area. In the lower reaches of the watershed, particularly in the Huron High

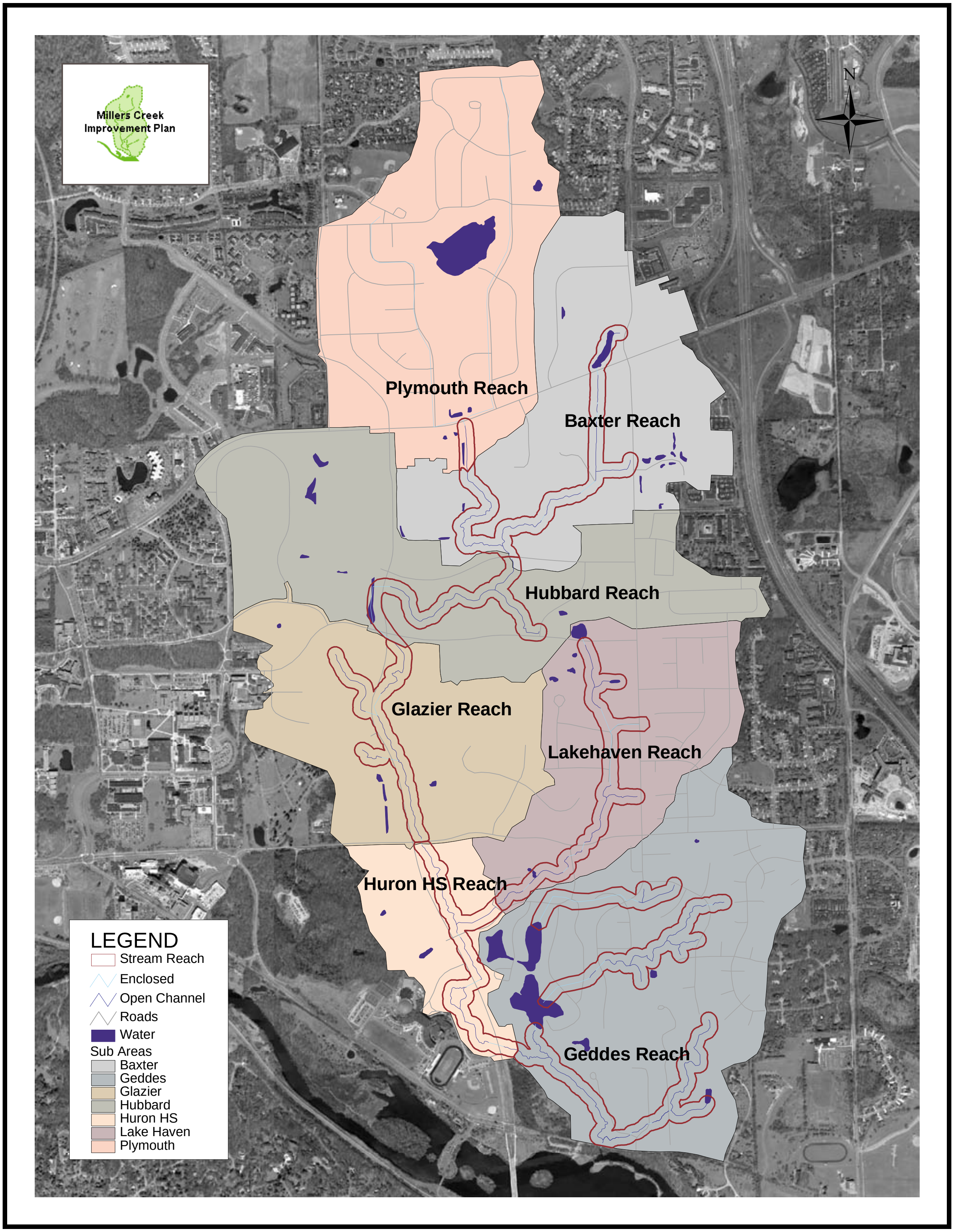

Figure 5.1 Millers Creek Reaches

School and Geddes subwatersheds, there are some significant areas of loamy sands that are probably alluvium or glacial outwash deposits.

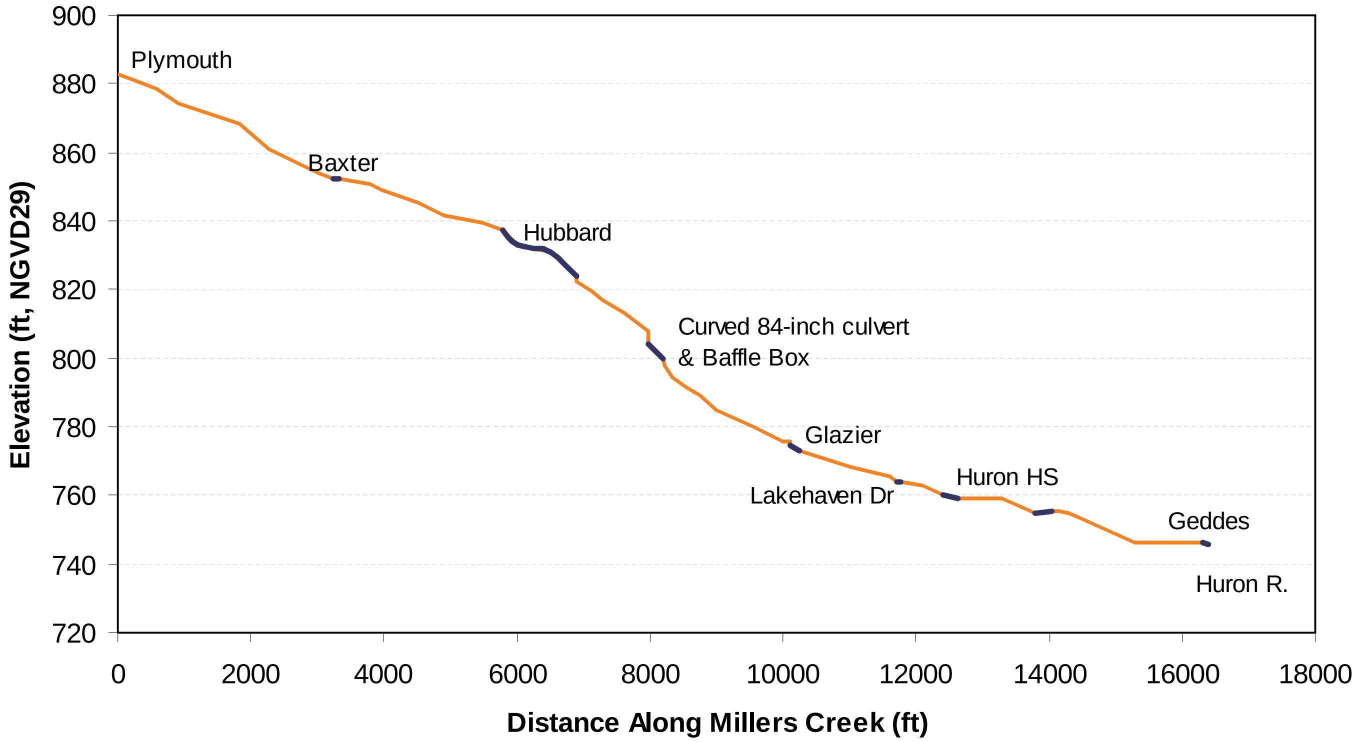

Figure 5.2 Elevation Change Along Millers Creek

Table 5.1 Millers Creek Soils (identified by SCS Texture Class) by Subwatershed

Hydrologic Soil Type	***Subarea***	***Plymouth***	***Baxter***	***Glazier***	***Hubbard***	***Huron HS***	***Lake Haven***	***Geddes***
	Total Subarea Area (ac)	275.86	241.04	196.43	258.73	80.55	170.10	308.52
A	*Loamy Sand*	0.0%	0.0%	8.3%	0.0%	36.8%	0.0%	0.0%
A	*Sandy Loam*	0.0%	0.0%	37.9%	3.0%	16.0%	4.2%	41.3%
B	*Loam*	0.0%	0.0%	0.0%	0.0%	0.0%	1.2%	2.4%
B	*Clay Loam*	96.8%	100.0%	53.8%	97.0%	23.6%	89.0%	53.7%
C	*Sandy Clay Loam*	0.0%	0.0%	0.0%	0.0%	1.1%	0.0%	0.1%
D	*Muck*	2.9%	0.0%	0.0%	0.0%	4.0%	4.9%	0.0%
D	*Fill*	0.0%	0.0%	0.0%	0.0%	18.5%	0.7%	2.4%
Impervious	*Water*	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Watershed Conditions

Approximately 40% of the 2.4 square miles (1,531 acres) of the Millers Creek watershed is covered by lawn or “urban savanna”, an urban or suburban landscape characterized by mowed lawn and trees, and may include shrub and perennial beds (See Table 5.2 below). Approximately 13% of the area is covered by roads, and another 10% of the area is covered by rooftops. Total impervious surface area is 35% (See **Figure 5.3**). Some of this impervious surface area drains off onto pervious areas, such as grassed or forested areas. However, almost 70% of this impervious surface area drains directly to Millers Creek or to storm sewer (Directly Connected Impervious Area (DCIA) = 24%). Much of the area infrastructure was built in the 1960’s and 1970’s before storm water detention was required. Even in areas where some ponds were built, no provision was made to detain smaller storms, such as the bankfull event (channel-forming event). In addition, most of the storm sewer is designed to be self-cleaning and does not have storage, e.g., catch basin sumps, to contain runoff sediment loads (See **Figures 5.4 and 5.5** for storm sewer and problem locations).

Table 5.2 Millers Creek Land Cover by Subwatershed

Subarea	***Plymouth***	***Baxter***	***Geddes***	***Glazier***	***Hubbard***	***Huron HS***	***Lake Haven***	***Total***
Total Subarea Area (ac)	**275.86**	**241.04**	**308.52**	**196.43**	**258.73**	**80.55**	**170.10**	**1531.23**
Detention Basin Wetland	0.2%	0.4%	0.0%	0.3%	0.7%	0.1%	0.0%	0.3%
Emergent Wetland	0.4%	0.6%	0.1%	0.0%	0.0%	0.3%	0.2%	0.2%
Forested Wetland	1.2%	1.7%	2.7%	5.5%	1.2%	11.9%	1.1%	2.7%
Meadow/Prairie	0.8%	10.0%	0.1%	2.2%	3.6%	4.0%	0.9%	2.9%
Open Water	2.4%	0.0%	3.1%	0.0%	0.0%	0.0%	0.2%	1.1%
Parking Lot	5.2%	23.0%	0.3%	9.4%	15.4%	3.2%	2.7%	8.9%
Roads	20.4%	7.0%	13.9%	9.1%	11.5%	11.5%	16.2%	13.1%
Roof Top	11.7%	12.2%	9.0%	3.4%	11.4%	4.6%	8.3%	9.4%
Scrub/Shrub Wetland	0.0%	2.1%	3.1%	0.5%	0.1%	0.3%	0.0%	1.1%
Shrub/Immature Woodland	0.6%	6.9%	2.0%	2.9%	7.0%	0.8%	4.8%	3.7%
Lawn	48.6%	33.4%	44.0%	28.9%	40.5%	23.7%	45.4%	39.7%
Wet Meadow	0.0%	0.0%	0.1%	0.1%	0.1%	0.0%	0.2%	0.1%
Woodland	8.0%	2.7%	21.2%	39.0%	8.4%	39.8%	19.7%	16.8%
Other	0.3%	0.0%	0.1%	0.1%	0.0%	0.2%	0.0%	0.1%

Approximately 37% of land use in the watershed is residential (see **Table 5.3** below). The next highest land use category is institutional (UM and Ann Arbor School property) at 23% of the watershed. The next two most significant uses are commercial and industrial at 19% and recreational area at 3.5%.

The commercial and industrial uses are located along the Plymouth Road corridor in the north area of the watershed. UM owns land throughout the watershed. Most of the watershed area is within the City of Ann Arbor, although several isolated pockets of Ann Arbor Township land are located towards the southern end of the watershed.

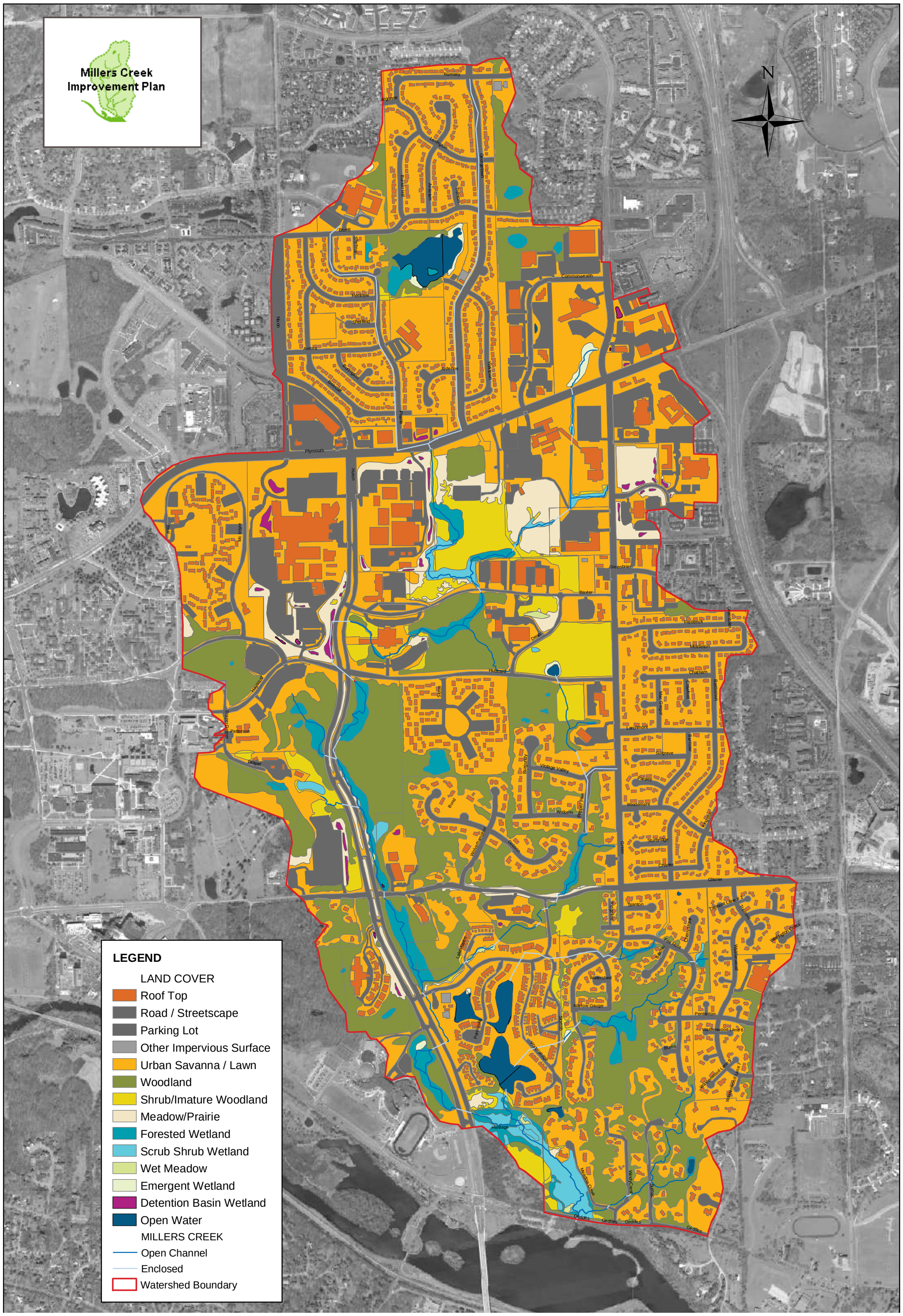

Figure 5.3 Existing Land Cover in the Millers Creek Watershed

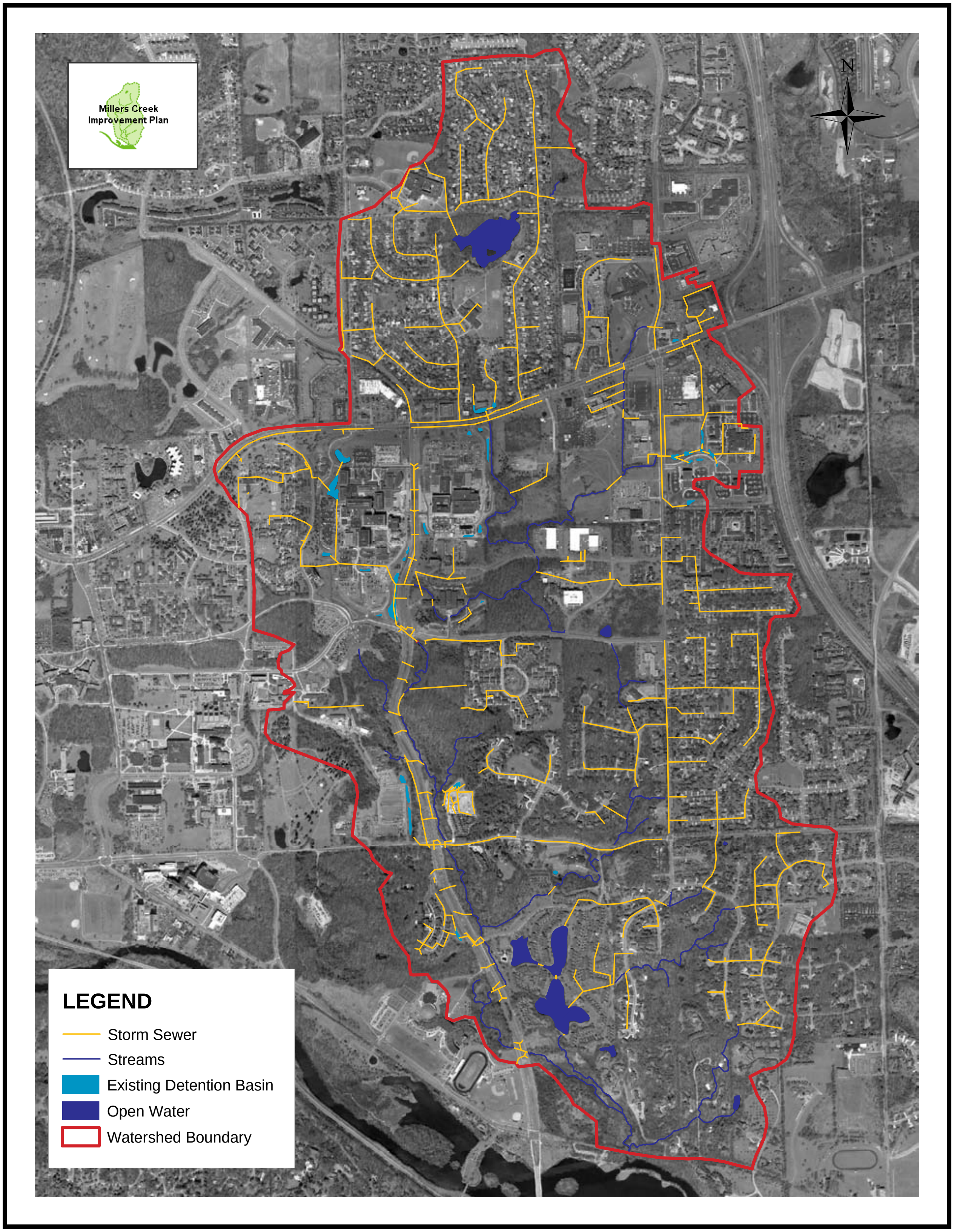

Figure 5.4 Storm Sewer in the Millers Creek Watershed

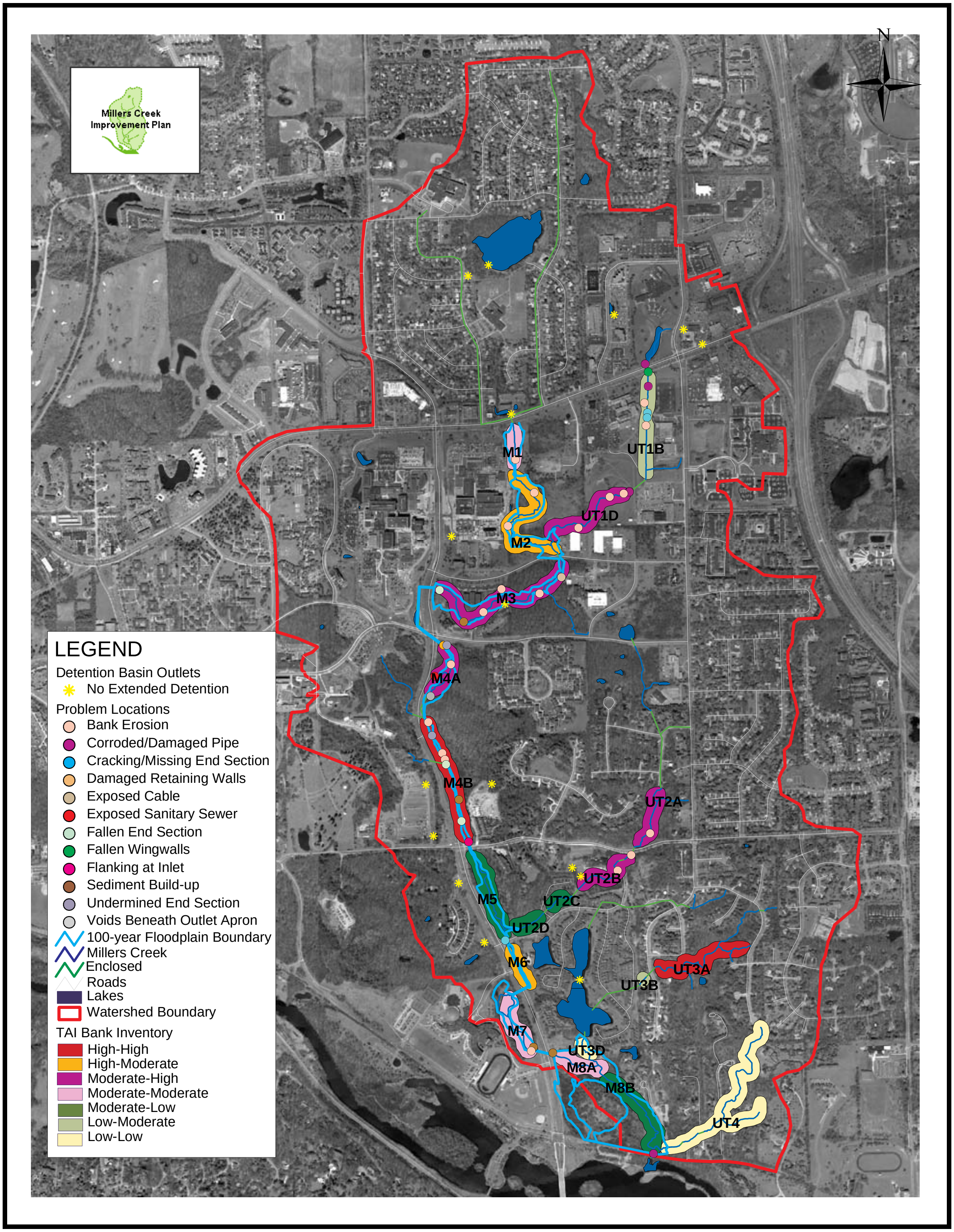

Figure 5.5 Problem Areas throughout the Millers Creek Watershed

Table 5.3 Millers Creek Land Use by Subwatershed

Subarea	*Plymouth*	*Baxter*	*Geddes*	*Glazier*	*Hubbard*	*Huron HS*	*Lake Haven*	*Total*
Total Subarea Area (ac)	275.86	241.04	308.52	196.43	258.73	80.55	170.10	1531.23
Commercial/ Industrial	14.1%	76.0%	0.0%	0.1%	25.7%	0.0%	3.2%	19.2%
Institutional	13.3%	16.3%	1.9%	53.5%	49.0%	20.6%	18.6%	23.6%
High Intensity Res.	0.3%	0.0%	12.0%	4.9%	5.1%	34.5%	2.6%	6.1%
Med Intensity Res.	47.2%	0.3%	16.7%	0.0%	6.7%	0.0%	29.3%	16.3%
Low Intensity Res.	0.0%	0.0%	42.6%	16.6%	0.0%	16.3%	27.0%	14.6%
Recreation	6.5%	0.0%	7.0%	0.0%	0.8%	10.7%	2.0%	3.5%
Utilities	0.2%	0.5%	0.7%	0.0%	0.0%	0.0%	0.0%	0.2%
Vacant/ Unknown	0.0%	0.0%	5.3%	13.8%	0.3%	2.3%	0.0%	3.0%
Roads	18.5%	7.1%	13.7%	11.0%	12.3%	15.7%	17.4%	13.5%

Hydrology

During the period from August 2002 to August 2003, the watershed received about 32 inches of rain. A continuous flow record from the pressure transducers at the Plymouth, Glazier and Meadows stations was collected between August 2002 and September 2003 (See **Appendix G** and **Table 5.4** below). Average annual daily flow at Plymouth was 0.35 cfs, but the continuous record showed that frequently the flow was near zero. Clearly, development north of this station has cut off much of the infiltration and the base flow from Thurston Pond (once the likely headwaters of the creek) and the upper part of the watershed. Interestingly, during dry weather the flow disappears under Huron Parkway just downstream of the University of Michigan Hospitals and Health Centers North Campus Administration Complex (2901 Hubbard). Dry weather flow “re-appears” downstream of the Pfizer restored wetland site coming out of the 84-inch culvert that passes under the intersection of Huron Parkway and the Hubbard/Hayward streets.

The Glazier and Meadows stations have nearly the same average annual daily flow at 1.20 cfs and 1.17 cfs, respectively. Summertime baseflows (groundwater contribution) for both stations were measured at approximately 0.7 to 0.8 cfs. Evidence of groundwater seeps, including oxidized orange-brown precipitant, has been seen at several locations below the Hubbard station. The Meadows station likely experiences the most overbank flow of these three stations. The lowest instantaneous peak flows of all three stations were recorded at Meadows and are probably the result of water “lost” to the floodplain during overbank flows.

The outlet elevation of Millers Creek is determined by the water level in the Huron River. Water elevation in the Huron River near Millers Creek is determined by the Geddes Dam (spillway elevation = 745.8 ft), located about 1.5 miles downstream of the creek (Township of Ann Arbor Federal Emergency Management Agency, 1979). During high flow periods in the Huron River, the backwater influence of the river can extend up Millers Creek to almost the Huron High School staff gage location.

A peak flow factor was calculated to illustrate creek “flashiness.” This factor equals the instantaneous recorded peak flow rate divided by the average annual daily flow. The Plymouth site is clearly the flashiest, with a very low mean flow (0.35 cfs) and very high peak flows (95.8 cfs recorded maximum) yielding a peak factor of 274. By comparison the peak factor at Glazier is 211 and 60 at Meadows. The lower peak factor at Meadows is again likely a consequence of overbank flooding diminishing peak flow magnitudes.

Table 5.4 Flow characteristics during continuous recording (August 2002-April 2003)

Station	Average Annual Daily Flow (cfs)	Peak Instantaneous (cfs)	Peak Factor (Peak Instant./Mean Daily)
Plymouth	0.35	95.8 (8-21-2003)	274
Glazier	1.20	252.8 (8-21-2003)	211
Meadows	1.17	70.9 (4-4-2003)	60

Geomorphology

One way to think of rivers and streams is as water and earth-moving machines that rely on the conversion of potential energy (elevation) to the kinetic energy of flowing water to move sediment. On Millers Creek, the natural tendency of the stream to move its watershed to its base level (the Geddes dam elevation in the Huron River) is being accelerated by development in the watershed. The creek is cutting the stream bed down, "pulling" more and more of the landscape down with it. The stream bed and banks are being carried downstream. The wetland at Huron High School and the wetland complex between the High School and the Geddes site are basically the stream delta, where the sediment dislodged upstream comes to rest. The total suspended solids data collected for this project corroborate this description (**see Figure 5.6** below). The data shows increasing average and peak TSS concentrations up to Huron High School and then a clear reduction of TSS concentrations at the Geddes station. Geomorphology data can be found in **Appendix I**.

The high bed slope combined with extensive Directly Connected Impervious Area (DCIA) has led to some extreme downcutting. The downcutting has disconnected some of the stream from its floodplain. Some of the Hubbard reach above the 84-inch curved culvert, and most of the reach from the baffle box at the end of the 84-inch culvert down to Glazier, is incised. These conditions have led to undercut storm sewer outlets, failed outlets, failing retaining walls and extreme bank erosion (See **Figure 5.7**).

Figure 5.7 Fallen end section in Glazier Reach

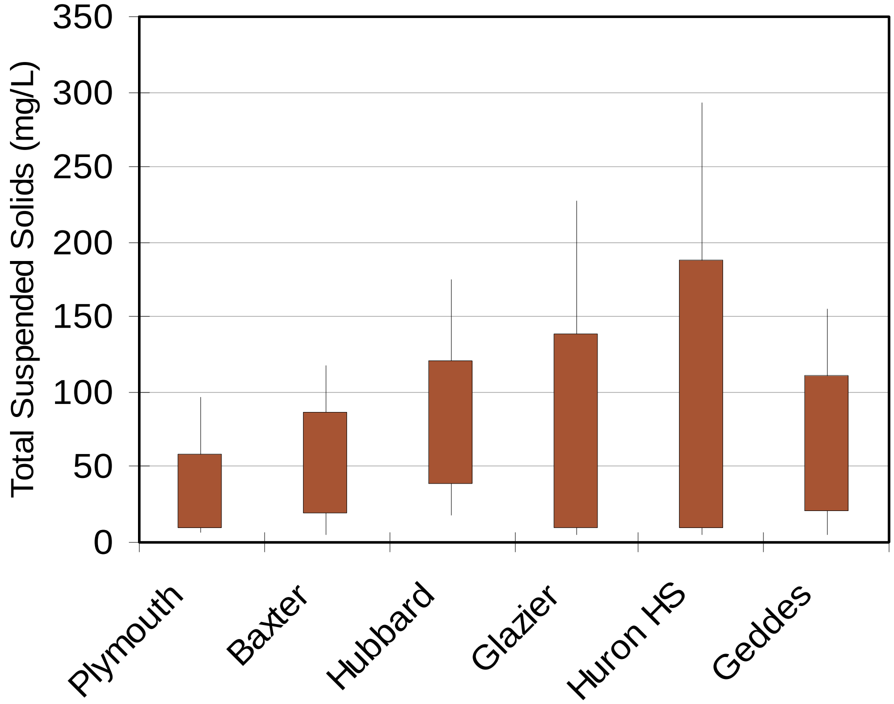

Figure 5.6 Measured Dry and Wet Weather Total Suspended Solids Concentrations
(top and bottom of bars = 25th and 75th percentile, top and bottom of lines = minimum and maximum concentrations)

Incision can be gauged by the Rosgen entrenchment ratio (See **Table 5.5** below). The entrenchment ratio equals the width of the channel at twice the bankfull depth divided by the width of the channel at bankfull depth. The more active a floodplain, the higher this ratio will be. When this ratio falls below two, there is little chance the stream ever reaches its floodplain. When a channel becomes completely disconnected from its floodplain, the flows, velocities and shear stresses are always concentrated within the banks, and channel response becomes even more dynamic and acute.

Incised channels are usually classified by Rosgen as F and G stream types. **Table 5.6** shows that except for the Plymouth cross-section, the areas of high velocity and shear stress are in reaches classified as F and G stream types. These are transitional stream types where active stream bank erosion and mass-wasting are feeding the stream high sediment loads. In time, when the channel has expanded sufficiently, these high sediment loads will become depositional features and promote development of a floodplain inside the existing channel.

Table 5.5 Rosgen Stream Classification Table for Representative Reaches

Name	Sec ID	Type	Bankfull depth (ft)	Bankfull Width (ft)	Bankfull W/d Ratio	Entrench-ment Ratio	Bed Slope (%)
Plymouth	37	E6	5.7	29.0	5.0	20.7	0.8
Baxter	30	E4	3.3	20.0	6.1	16.9	0.4
Hubbard – Up	26	E5	3.5	17.8	5.1	6.6	0.8
Hubbard - Dn	25	F4	3.0	29.0	9.7	1.2	1.7
Glazier - Up	21	F4	2.3	57.0	24.5	1.2	1.9
Glazier - Dn	18	G4c	5.1	30.0	5.9	1.5	0.9
Huron HS - Up	14	C5	3.5	39.0	11.1	4.6	0.5
Huron HS - M	11	E5	3.0	13.0	4.3	4.3	0.3
Huron HS –Dn	6	E5	2.8	11.2	4.0	33.5	0.3
Meadows	4	E6	2.6	11.4	4.4	14.6	0.9
Geddes	1	E6	2.6	15.1	5.7	24.0	-0.3

Table 5.6 Existing Velocity and Shear Stress for Bankfull Event

Name	Sec ID	Velocity (ft/sec)	Shear Stress (lbs/ft^2)	Shear Stress (N/m^2)
Plymouth	37	5.47	1.23	58.89
Baxter	30	3.41	0.86	41.18
Hubbard – Up	26	4.05	0.56	26.81
Hubbard - Dn	25	3.42	1.82	87.14
Glazier - Up	21	3.57	1.01	48.36
Glazier - Dn	18	5.56	1.33	63.68
Huron HS - Up	14	3.28	0.50	23.94
Huron HS - M	11	4.57	0.54	25.86
Huron HS –Dn	6	4.03	0.15	7.18
Meadows	4	2.12	0.61	29.21
Geddes	1	1.88	0.59	28.25

Some floodplain connection still exists between the Plymouth and Baxter sites, along the reach between Baxter and where Millers Creek first goes underneath Huron Parkway (just east of the Pfizer mitigation wetland) and south of Glazier down the Huron River. The reaches that still have an active floodplain, with the exception of the reach between Glazier and Lake Haven, are all classified as a Rosgen E4, E5 or E6 stream type (See **Table 5.5** above). The E-type (the numbers 4, 5 and 6 indicate that the median stream bed particle size is gravel, sand or silt/clay, respectively) generally has a stable bed and planform, unless the stream banks are disturbed and significant changes to the sediment supply and/or streamflow occur. The Plymouth reach is somewhat of an exception to this assessment because the channel has been straightened and the bed is composed mainly of clays. There are localized high velocities and shear stresses in this area due to channel straightening and high upstream flows, but these high velocities and shear stresses are causing localized bank erosion and are part of the reason that the banks near Pfizer's ponds have been failing. The clay bed has prevented local downcutting.

Water Quality (refer to Appendix A for data)

All sites had an average summer stream temperature below 72°F, which is the warmest water that will support cold-water fish, such as sculpin and trout (Wehrly et al., 2003). The sites at Glazier Way and Baxter Road are “cold” sites with temperatures averaging below 66.2°F. The remaining 6 study sites are “cool,” averaging between 66.2°F and 71.6°F. All sites experienced a moderate fluctuation in summer temperature, as defined by a difference of less then 5°F between the average minimum and average maximum stream temperature. These values verify that Millers Creek still receives some healthy groundwater base flow.

The range of conductivity values in some areas of Millers Creek is extremely broad (See **Table 5.7**). Both the highest and the lowest values seen in the entire Huron system have been found at the Plymouth Road site, ranging from 166 µS (which is comparable to rainwater) to 34,700 µS, (which approaches the conductivity of saltwater). Although the low conductivity values at Plymouth are a bit of a mystery, the high values could be due to salt washoff into the creek or concentration of salts at this station during low flows. As noted above, flow at the Plymouth station can approach zero. If flows remain near or at zero for a long enough period of time, salts could become concentrated as water is lost back to the atmosphere by evaporation. Narrow Gauge Way is the only site where the conductivity is within the expected range for the Huron watershed.

Table 5.7 The minimum, maximum and average conductivity on Millers Creek

# on map	LOCATIONS	Min Conductivity	Max Conductivity	Avg Conductivity	# Samples	Years studied
4	Glazier Way	1,120	4,360	2,202	31	1995-2002
1	Plymouth Road	166	34,700	6,453	19	2002-2003
2	Baxter Road	475	15,240	3,198	9	2002-2003
5	Lakehaven Court	948	1,474	1,190	9	2002-2003
6	Narrow Gauge	647	992	754	6	2002-2003
7	Huron Parkway	1,017	2,270	1,660	8	2002-2003
3	Hubbard Road	733	7,920	3,068	6	2002-2003
8	Meadows	560	2,470	1,771	20	2002-2003

E. coli results (See **Figure 5.8**) indicate two likely problem areas: north of the Plymouth site (maximum = 18,000 counts/100 ml) and north of the Glazier site (maximum = 16,000 counts/100 ml). The state standard for these concentrations is 130 counts/100 ml for the 30-day mean and 300 counts/100ml for the daily mean. MDEQ sampling in 2002 (See **Appendix A** for data) also confirmed high counts in the vicinity of the Plymouth site. These high counts may be caused by animal influences (geese, raccoons, etc.), storm and sanitary storm sewer cross-connections in upstream or stagnant water. E. coli can reproduce in sediments and periods of stagnant water at Plymouth could foster growth and increase sampled counts. The high Glazier value may have been caused by an uncovered sanitary storm sewer crossing located upstream. UM has recently confirmed that this sanitary sewer crossing is in active use. UM, with the help of the City of Ann Arbor, is investigating solutions to repairing this line.

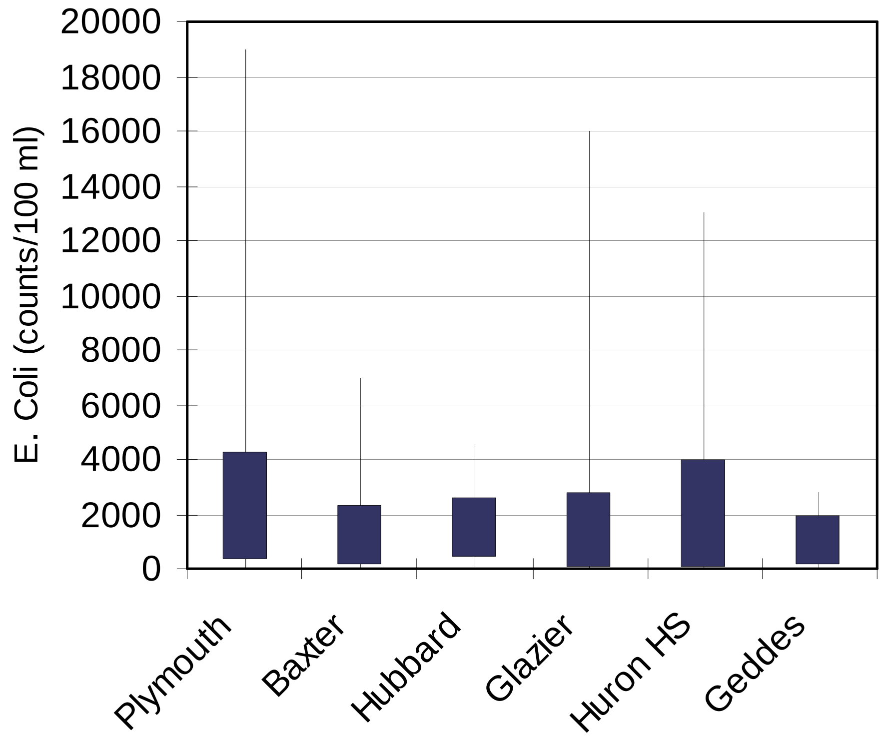

Figure 5.8 Measured Dry and Wet Weather *E. Coli* Concentrations (top and bottom of bars = 25th and 75th percentile, top and bottom of lines = minimum and maximum concentrations)

Total phosphorus and dissolved orthophosphate concentrations (See **Figures 5.9 and 5.10**) also appear high, with the Plymouth site again yielding the highest concentrations. These high concentrations may also be partly a result of upstream sewer cross-connections, animal influence or stagnant water. Again, evaporation from standing pools will concentrate chemical constituents and may play a role in some of the high phosphorus concentrations.

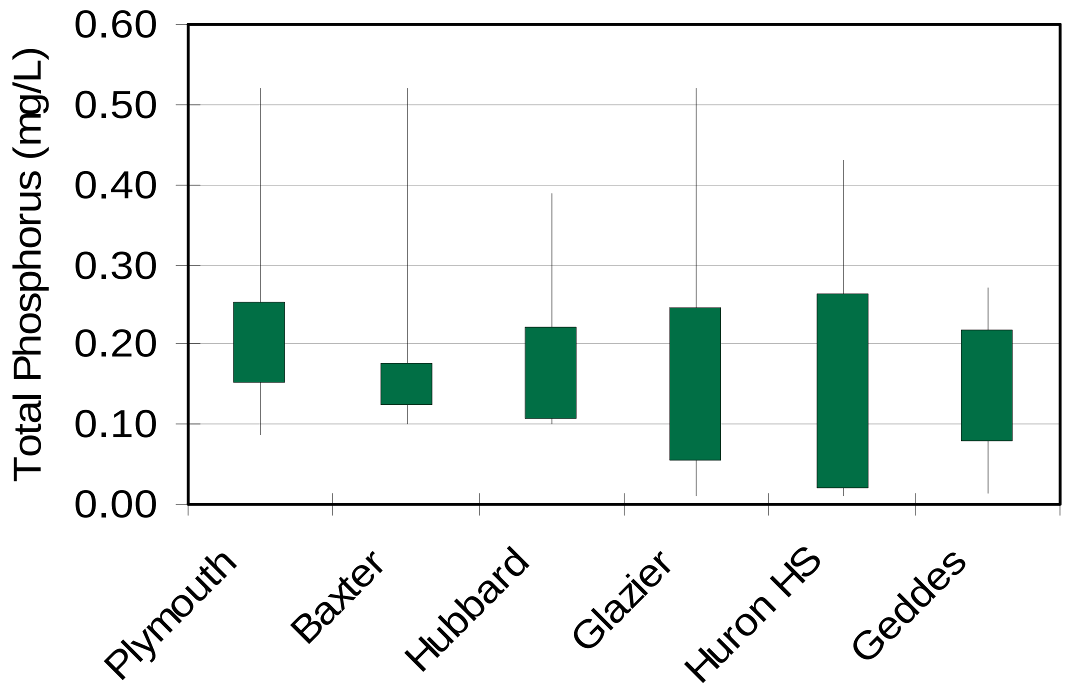

Figure 5.9 Measured Dry and Wet Weather Total Phosphorus Concentrations (top and bottom of bars = 25th and 75th percentile, top and bottom of lines = minimum and maximum) concentrations)

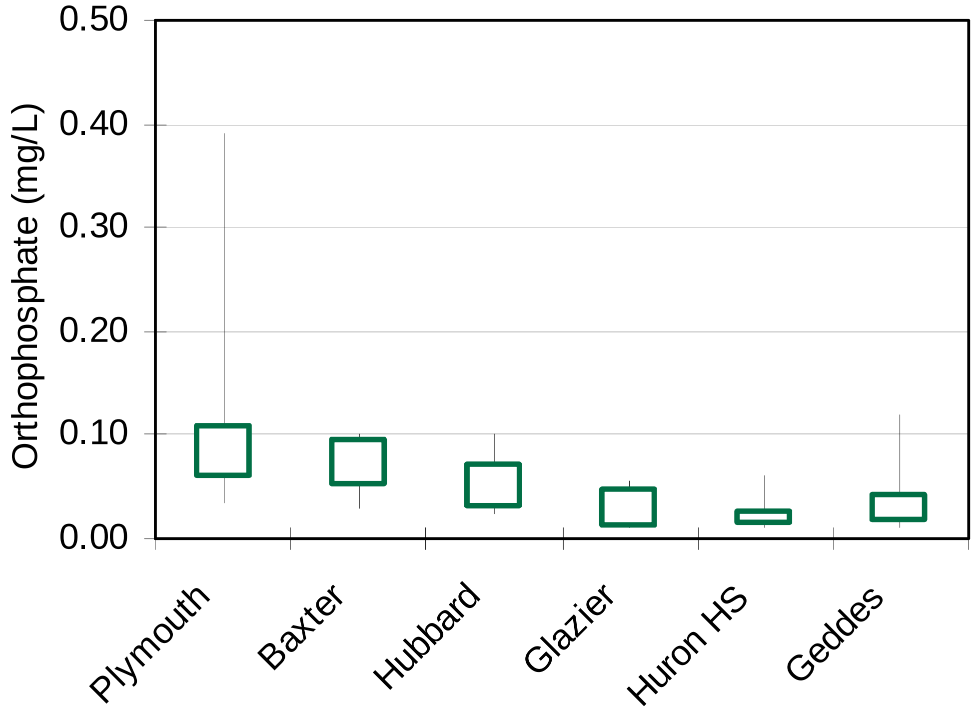

Figure 5.10 Measured Dry and Wet Weather Orthophosphate Concentrations
(top and bottom of bars = 25th and 75th percentile, top and bottom of lines = minimum and maximum concentrations)

Macroinvertebrate Population / Habitat

In general, Millers Creek is in poor physical condition and appears to support an impoverished macroinvertebrate population (See **Appendices J and K**). With the high gradient and extremely flashy conditions, small storms that occur several times a year may result in significant movement of stream bed material, disturbing the substrate and preventing reestablishment of the benthic community. Wiley et al. (1997) found that it could take 2-3 generations for an aquatic community to recover from such a hydrologic disturbance. In much of the creek, storm flows have eroded the stream channel and destroyed habitat.

The Plymouth Road site is the most impoverished of the eight study sites on Millers Creek, supporting on average of only four insect families. Of the sites with continuous flow data, it is also clear this is the flashiest site, with extremely low flows transformed into very high peak flows in a matter of minutes. Only one EPT family, the small minnow mayfly (Family Baetidae), was found during the three macroinvertebrate surveys. Sensitive families were not found at this location. The site at Baxter Road offers the best physical conditions yet still appears to support an impoverished population.

With the exception of the Glazier Road study site, insufficient data is available to assess the biological conditions at Millers Creek study sites. Preliminary data suggests an overall lack of EPT families and sensitive families. However, a sensitive family was found at Meadows, and two were found at the Narrow Gage Way study site. In addition, two families of winter stoneflies were found at the Narrow Gage Way site in 2003.

Corridor Condition

A diversity of upland and wetland plant communities including woodland, shrubland, and meadow are present along the creek corridor. In many locations, natural plant communities extend well beyond the 200-foot wide corridor (See **Figure 5.11**). Urban land cover including significant areas of road, lawn and building encroachments are also present. Cover types within the corridor are summarized in **Table 5.8**. Dominant cover types are woodlands including forested wetlands and urban savanna\lawn. Tree species present in the woodlands are consistent with presettlement oak-hickory and mixed oak plant communities. Invasive shrubs such as buckthorn, honeysuckle and autumn-olive dominate the shrub layer throughout the corridor. Herbaceous vegetation is dense in some portions of the corridor and nonexistent in others. In general, herbaceous vegetation on the creek banks is minimal due to erosion and dense shade from woody invasives. Overhanging vegetation or stream canopy coverage ranges from 0 to 100% depending on location. Coverage is sufficient over much of the creek, but in many locations, woody invasives comprise a significant portion of that coverage.

While much of the streamside vegetation has degraded significantly, areas of high quality vegetation can still be found in the corridor. Seepage wetlands along the main stem and the tributary originating near Narrow Gauge Way Road contain diverse species such as skunk cabbage, marsh marigold, and red twig dogwood. Mature forests contain diverse tree species and some very large oaks. An extensive wetland complex with intact floodplain can be found at the creek's confluence with the Huron River.

Table 5.8
Summary of Cover Types Within 200 Foot Wide Stream Corridor

CORRIDOR COVER TYPE	RANK	AREA (ACRES)	PERCENT COVER
Woodland	1	47.0	29.8%
Forested Wetland	2	29.4	18.6%
Urban Savanna / Lawn	3	28.2	17.8%
Scrub Shrub Wetland	4	14.1	8.9%
Road / Streetscape	5	12.1	7.6%
Shrub/Immature Woodland	6	11.4	7.2%
Meadow/Prairie	7	7.5	4.7%
Parking Lot	8	2.6	1.7%
Roof Top	8	2.4	1.5%
Emergent Wetland	9	1.8	1.1%
Wet Meadow	10	0.8	0.5%
Detention Basin Wetland	11	0.2	0.2%
Open Water	11	0.3	0.2%
	TOTALS	157.8	100%

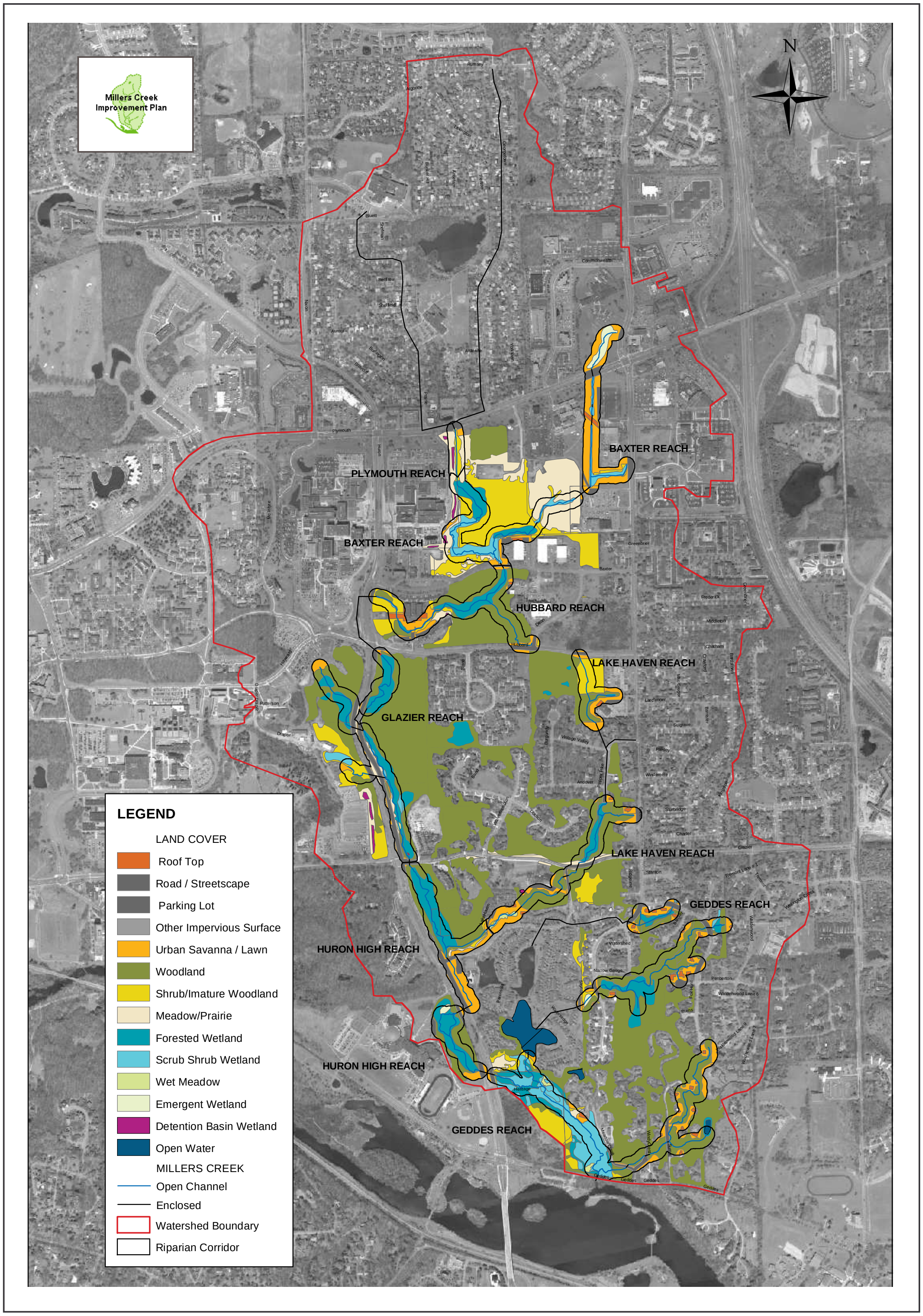

Figure 5.11 Riparian Corridor Land Cover and Contiguous Natural Plant Communities

6. IMPROVEMENT PLAN

The mission of the MCAT is to work together to establish and implement socially, environmentally, and economically sustainable watershed management standards and practices that will improve the quality of the Millers Creek Watershed. The emphasis of this mission statement is based on two broad goals for the watershed: 1) creation of sustainable watershed standards and practices, and 2) improvement of the watershed and the creek.

This Millers Creek Watershed Improvement Plan contains a core list of watershed improvement opportunities. Rather than first identifying a select set of specific implementation projects, the project team identified as many reasonable opportunities for improving Millers Creek and then prioritized a subset of those opportunities for the ten-year implementation plan.

The use of the term opportunity is a deliberate characterization of the activities identified in this plan. This plan and the identified opportunities are not mandatory actions that stakeholders must implement, but rather a set of recommended options for achieving the plan objectives. The costs for implementing all the recommended opportunities currently exceed the funding capacity of all watershed stakeholders. Implementation, particularly significant structural best management practices (BMPs), will have to rely on leveraging opportunities as they arise, both from outside funding sources and in response to changing circumstances within the watershed such as redevelopment or property ownership transitions.

Both qualitative and quantitative assessment measures were used to evaluate the feasibility and impacts of proposed improvements. The qualitative assessment judged feasibility on the adversity of technological challenges, engineering design requirements (e.g., level of complexity), property ownership and management, public acceptance, and potential site constraints. The calibrated hydrology, hydraulic and water quality models were used to quantify the extent to which the flow and water quality objectives were met by the major improvements identified by this plan.

For the quantitative assessment, five alternative evaluation scenarios were developed. The first alternative scenario was simply an assumed, completely built-out condition. The next three alternative scenarios were variations of deployment strategies for a series of BMPs in the watershed. The fifth alternative scenario consisted of analysis and consideration of various stream bed and stream bank restoration scenarios.

The improvement opportunities were presented to the public during the last Millers Creek public meeting on July 23, 2003. The public was asked to discuss the improvement opportunities with the project team and provide feedback. MCAT received some encouraging discussion with workshop participants on specific recommendations. One specific recommendation from the workshop participants that the project team worked to re-emphasize is recreational opportunities. The Millers Creek action team will continue to provide the public with opportunities to comment and work on specific projects as they are considered for implementation.

6.1 Watershed Management Objectives

In order to develop the Millers Creek Improvement Plan, it was important to first identify specific objectives that could lead to successful goal attainment. Specific actions were then identified and designed to meet the specific objectives. This process was used to ensure that the proposed actions would be able to objectively achieve the goals of the improvement plan. As such, this implementation plan is consistent in terms of matching practical actions with appropriate and measurable objectives, and appropriate and measurable objectives with identified improvement goals. The project objectives are summarized below:

1) **Watershed Land Use and Management**
   Objectives: Maximize land preservation and minimize directly connected impervious area while directing unavoidable development in ways that protect important watershed processes and water resource functional values. Improve land cover where possible by reducing impervious surfaces, establishing forests and prairies, reducing turf grass, and planting trees.

2) **Hydrology**
   Objectives: Maximize the amount of storm water captured, detained, and treated. Reduce bankfull peak flows, the channel forming flows, by at least 50%.

3) **Water Quality**
   Objectives: Decrease overall pollutant loading to Millers Creek as much as possible. Decrease total phosphorous loading by 50% from existing conditions (per Ford and Belleville Lakes TMDL). Reduce *E. coli* numbers in surface waters to the state water quality standard of a summer (May to October) 30-day geometric mean of 130/100 ml (per Geddes Pond TMDL).

4) **Fish and Wildlife Habitat**
   Objectives: Increase biological diversity of terrestrial and aquatic wildlife by improving habitat, reducing or eliminating habitat impacts, and conserving critical habitats. Habitat shall be rated good by the standard GLEAS procedure.

5) **Public Understanding and Support**
   Objective: Develop and maintain project support by promoting public awareness, understanding, and stewardship. Offer effective opportunities for public education, training, input, and participation. Provide readily available technical and information-based resources.

6.2 Methodology

6.2.1 Qualitative Feasibility Assessment

The first step in identifying improvement opportunities was to define a set of available watershed improvement tools based on available technology and accepted watershed management practices. **Table 6.1** presents seven categories of watershed improvement tools and several practices that fall within those categories. The categories and practices are discussed below in more detail.

The second step was to identify sites in the watershed where these practices could be applied. This process involved the use of GIS and field reconnaissance. Potential sites were identified based on several observable site characteristics including size, land use, presence of existing storm water features, location, and physical constraints. During the process, the team specifically looked for ways to achieve project goals and objectives through identifiable improvement sites. The process was conservative in terms of omitting sites or failing to identify potential sites. This strategy was used to ensure that we were including opportunities that could be eliminated later through more detailed feasibility analyses rather than omitting sites that might provide a potential benefit(s) to Millers Creek.

Table 6.1 Available Technological Controls, Best Management Practices, and Resource Improvement Methods

Stormwater Practices	Stewardship	Regulatory & Administrative Practices	Stream Enhancement	Land Conservation	Soil Erosion & Sedimentation Control	Native Landscape Restoration
Detention Basin Retrofit	Drain Stenciling	Low/No P Fertilizer Ordinance	Buffer Establishment	Open Space Preservation	Inspection & Enforcement	Reforestation
New Detention Basin	Fertilizer & Pesticide Use Reduction	Detach Roof Drains	Buffer Protection	Park Expansion	Containment	Wetland Restoration
In-line Treatment & Storage	Low P Fertilizer	Detach Footing Drains	Habitat Improvements	Natural Area Protection	Better Site Design	Native Prairie Establishment
Infiltration Swales	Rain Collection	Yard Waste Management Programs	Streambank Stabilization	Better Site Design	Street Sweeping	Invasives Removal
Infiltration Basin	Disconnect Roof Drains	Better Site Design	Daylighting	Sustainable Development		
Structural Improvements	Turf Grass Reduction		Grade Stabilization	Land Acquisition		
Wetland Creation	Tree Planting			Development Rights		
	Volunteer Monitoring					
	Public Education					
	Adopt-a-Stream					

To evaluate relative feasibility, the team used five criteria to assign a feasibility level from 1 to 5, one being most feasible and five being least feasible. This evaluation was not conducted to determine if a project could be implemented, only to assess the relative ease at which one could be implemented based on the five criteria. The five criteria are technological challenges, engineering design requirements (e.g., level of complexity), property ownership and management, public acceptance, and potential site constraints.

In addition to the feasibility assessment, each opportunity was qualitatively assessed based on its agreement with project goals. This assessment ensured that all five goals were thoroughly addressed and indicated which goals the opportunity was most applicable to. **Figure 6.1** shows the location of all the identified improvement opportunities. Refer to **Appendix L** for a brief description of each identified opportunity, the qualitative feasibility ranking and goal attainment assessments, and the modeled alternative number.

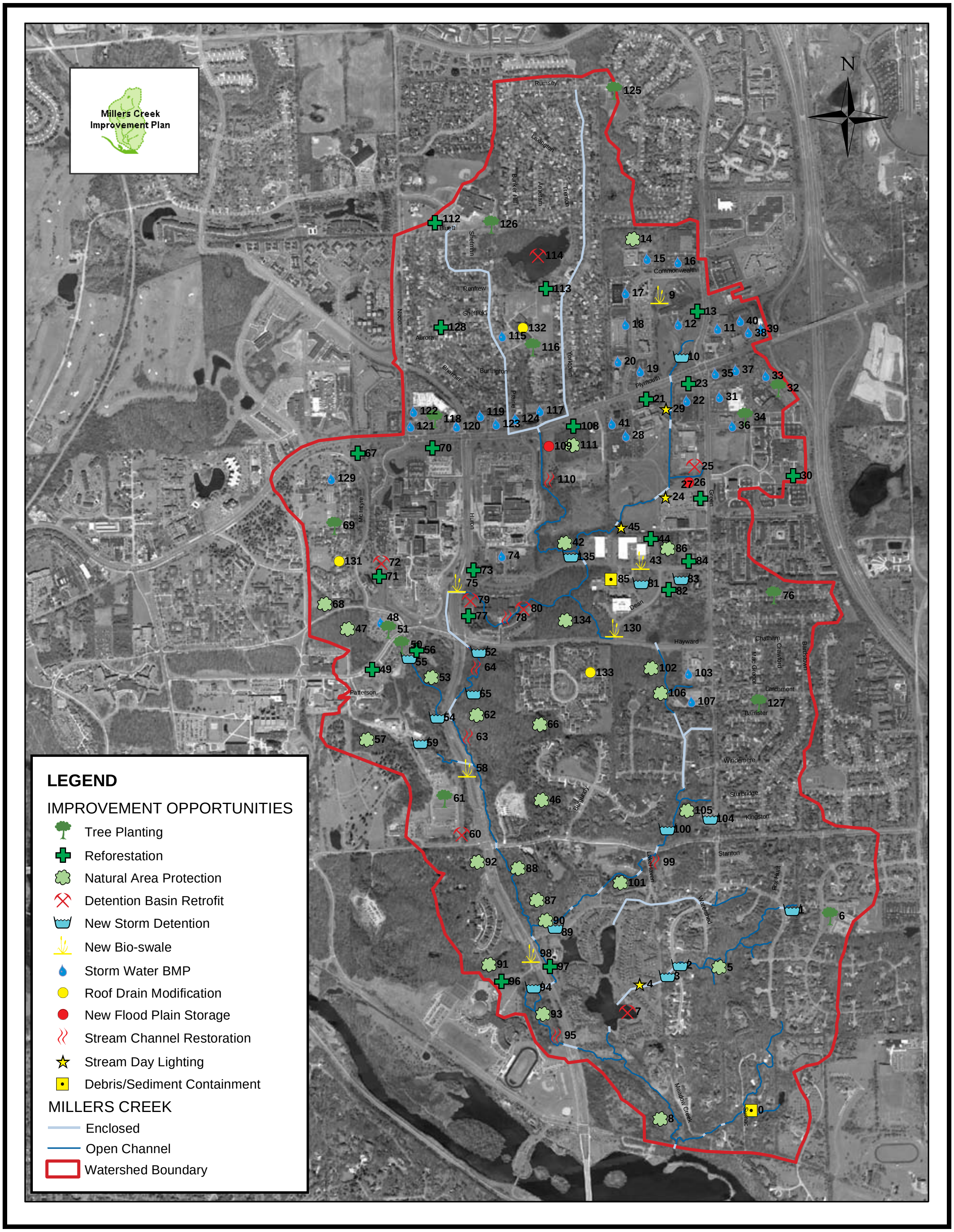

Figure 6.1 Locations of All Identified Improvement Opportunities

A total of 112 opportunities were identified and ranked. The opportunities are identified by watershed tool category and by ID number on **Figure 6.1** and are cross-referenced with the opportunity list in **Appendix F**. **Table 6.2** breaks out the opportunities by watershed tool category.

Table 6.2. Number of identified improvement opportunities by watershed tool

Watershed Improvement Tool Category	Number
Stewardship	20
Land Conservation	23
Structural Stormwater Practices	39
Stream Enhancements	9
Native Landscape Restoration	14
Soil Erosion and Sedimentation Control	5
Administrative Practices	2
TOTAL	**112**

6.2.2 Quantitative Goal Assessment

The degree to which the recommended improvements achieved flow and water quality control objectives was assessed with a set of five specific improvement scenarios. For these scenarios major improvement opportunities were grouped together by sets (or class) of improvement attributes and analyzed with the calibrated hydrologic/hydraulic and water quality models. The five alternative simulations, as defined by improvement opportunity classes, are:

1. Build-out conditions
2. Reforestation and Drain Disconnects
3. New Storm Water Detention and Detention Pond Retrofits
4. Additional Storm Water Detention, Detention Pond Retrofits, Proprietary Water Quality BMPs and Huron HS Sediment Trap
5. Construct boulder drops at the 84-inch culvert at the Hubbard site and at the outlet of the curved culvert above the Glazier site

Descriptions of the modeling scenarios are included in Chapter 7 below.

6.3 Watershed Improvement Tools and Practices

Structural Storm Water Practices

Often referred to as “best management practices” or “BMPs,” structural storm water practices are infrastructure designed and constructed to collect, store, infiltrate, and treat storm water. Structural storm water practices are some of the most expensive watershed improvement tools to implement and require perpetual maintenance. According to Schueler and Holland (2000), the cost to maintain a storm water practice over 20 to 25 years can be equal to the initial construction costs. Despite the high construction and maintenance costs, structural storm water practices can be effective tools for pollutant removal, runoff reduction, and peak flow reduction when properly designed, constructed, and maintained. The following practices have been recommended for Millers Creek.

Detention Basins
A detention basin is a constructed basin that receives, temporarily stores, and then gradually releases storm water. Detention basins are designed to pass a large volume of water through the channel network over a longer period, thus reducing the peak in-stream flow. Detention basins can also be designed to treat storm water during storage by removing sediments, nutrients, and contaminants. Older detention basins may no longer function properly due to inadequate maintenance or may lack contemporary improvements that improve function, such as extended detention outlet structures. The function of existing detention basins can be improved by altering the outlet structure, planting vegetation, removing sediment, and altering flow-through patterns. Retrofitting existing detention basins can be cheaper than constructing new detention basins.

Retention Basins
A retention basin is similar to a detention basin but is designed to indefinitely store storm water without a direct outlet to surface water. Detention basins can treat storm water but their effectiveness varies considerably. During storm events, a detention basin may only be able to remove a small percentage of the pollutants. The balance of the pollutants is discharged into the receiving water body. In contrast, retention basins receive and store storm water from a drainage basin without discharging to the receiving water body. Therefore, retention basins can consistently prevent most of the watershed pollutants from reaching the receiving water. Typically, these basins must be significantly larger than detention basins in order to store two back to back 100-year design rain events.

Bio-swale
A bio-swale, or grassed swale, is a type of conveyance channel designed to reduce surface flow velocities and remove pollutants from storm water through settling, adsorption, biological uptake, and infiltration en route to receiving water.

Tree Planting
Tree planting is intended to increase the density of trees in managed landscapes where trees already exist or establish trees where they do not exist. Both residential and commercial landowners can plant trees to increase rainwater interception and lower peak flows in the Creek. Tree planting is a recognized storm water BMP. Trees intercept rain before it hits the ground, help enhance infiltration with their root systems and lower air temperatures in their immediate vicinity. Small tree planting projects can be completed by almost anyone.

Roof Drain Disconnect
Roof drains in residential communities are often directly connected to the storm sewer network or discharge onto impervious surfaces (sidewalks and driveways) that are directly connected to the storm sewer network. Redirecting down spouts onto pervious surfaces or storing rainwater in rain vessels (e.g., rain barrels, rain cisterns) reduces storm water runoff volume.

Proprietary BMPs

Space constraints in developed areas often limit the options for storm water BMPs. This is particularly true around the commercial developments of the Plymouth Road corridor in the Millers Creek watershed. In these instances, below-ground proprietary BMPs can provide some storm water treatment, although they do not provide storage. Proprietary BMPs are pre-manufactured structures, such as concrete vaults or manholes with specialized weirs and filters that are installed as in-line or off-line treatment systems within the storm sewer network. They also include specialized chambers that can be installed in place of existing catch basins. Proprietary BMPs are recommended throughout the older commercial areas along Plymouth Road.

Stewardship Practices/Public Involvement
A stewardship program that includes public education, public participation, and environmentally friendly property management is highly recommended for Millers Creek. The community must support the improvements for the creek if they are to be effective, especially in view of the high costs of the construction and maintenance of structural improvements. Concern and support by the public are immeasurably enhanced by personal experience of the creek. An experience as simple as a tour of Millers Creek elicited one woman to say that while her congregation originally resented the City requirement that her church construct an expensive retention pond when expanding their parking lot, she could now see why it was necessary. People must know about the creek in order to respond to requests for its support. Many people will work hard to help make the community better if they understand what to do and how it will help. Such stewardship reduces the cost of improvements and generates commitment to the project.

The key to successful voluntary programs is effective leadership and organization. HRWC has shown the power of voluntary stewardship in many creeks including the study phase of the Millers Creek project. Residents have already donated approximately $40,300 in labor costs by collecting data on the conditions of Millers Creek. Many people worked in the rain and during odd hours to measure flow during peak flow events. Hundreds of people turned up reliably, regardless of the weather, to monitor the biotic health of the creek. Many of those people changed their yard maintenance practices as a result of their experience and accompanying education by HRWC. Voluntary programs under effective leadership are essential to the improvement of Millers Creek.

Regulatory and Administrative Practices
Local units of government (LUGs) are charged with the task of correcting water quality and water use impacts within their communities. In particular, LUGs have storm water management responsibilities under the federal “National Pollutant Discharge Elimination System” (NPDES) program of the federal Clean Water Act. This program is implemented by the State of Michigan under its Phase I and Phase II storm water permitting authority. In addition, the middle Huron River phosphorus TMDL and the Geddes Pond *E. coli* TMDL require compliance by the affected LUGs. The City of Ann Arbor, Ann Arbor Township, the University of Michigan and Washtenaw County (Drain Commission) are ultimately responsible for implementing storm water improvements that meet these requirements.

One way LUGs address these issues is through regulatory and administrative practices such as storm water and fertilizer ordinances. In contrast to the voluntary action encouraged under stewardship programs, regulatory and administrative practices establish the legal basis for LUGs to require compliance. Enforcement is accomplished through inspections, fees, and penalties. While high voluntary participation through stewardship is more desirable, regulatory and administrative practices are often required to effectively control water quality and use impacts to the extent that LUGs can meet their regulatory responsibilities. The following practices have been recommended for Millers Creek.

County Drain Designation

Millers Creek is not a designated County Drain. However, it is possible that Millers Creek, or portions of the creek, could be designated as a County Drain during implementation of the plan. Drain designation is a legal process where by a drain easement is established along the creek. This process can be controversial, could take years to complete, and would most likely be permanent given the societal needs for storm water conveyance in the Millers Creek watershed. The designation can be removed according to the current drain code, but the drain must no longer serve a useful purpose; this is not likely in Millers Creek. However, drain designation will improve access, allow drain improvement projects to be petitioned by the public, provide for a long-term maintenance program and will provide funding sources through grants and special assessments.

The current Washtenaw County Drain Commissioner, Janis Bobrin, leads a very progressive drain program that has integrated water quality goals, objectives and practices into their design standards. This programmatic philosophy is consistent with the goals and objectives of this project. There is some uncertainty associated with the longevity of this progressive stance because the Drain Commissioner's position is an elected office. However, the history of the County Drain Commissioner's office locally, including Washtenaw, Livingston, Oakland and Wayne Counties, has been a steady improvement of programs oriented towards protecting natural resources. In the opinion of the project team, given this climate it is highly unlikely that any of these programs, including Washtenaw County's, will relax their environmental standards. On the contrary, it is more likely that these programs will continue to improve their standards.

We recommend that LUGs consider petitioning the Drain Commissioner to designate Millers Creek as a County Drain. This will provide a permanent structure for identifying and implementing many of the improvements in this plan. This will also provide permanent administrative and maintenance attention on the creek.

Ordinances

Ordinances provide the legal basis for LUGs to require certain practices within their jurisdictions. Ordinances are used to control and oversee fertilizer application, storm water management, and land development (land use). The City of Ann Arbor has a storm water ordinance that applies to storm water management in Millers Creek. The City of Ann Arbor and Ann Arbor Township have land use ordinances that apply to Millers Creek. The City is also drafting a fertilizer application ordinance for consideration by the City Council. There is also an effort to pass a state-wide no-phosphorus fertilizer bill to control phosphorus at the level of fertilizer suppliers. Effective design and implementation of such ordinances are important to improving Millers Creek. Unless the effort to pass a bill restricting fertilizer phosphorus content at the state level is successful, we recommend that the City continue to pursue a fertilizer application ordinance that controls the use of fertilizers containing phosphorus.

Septic System Inspection Programs

Private, residential septic systems are often not maintained properly, leading to failure. Failed septic systems can leach bacteria and nutrients into ground water or allow these contaminants to be exposed at the surface and washed into receiving streams during storm events. LUGs have dealt with this growing problem by requiring septic inspections during real estate transactions. Improperly functioning systems must be replaced prior to completion of, or as a stipulation of, the real estate transaction. Washtenaw County already requires septic system inspections in rural areas outside the jurisdiction of local municipalities. Ann Arbor Township should consider requiring inspections every 3 to 5 years regardless of property ownership turnover. Ann Arbor Township should also consider requiring dye testing at the time of sale of residential properties. The only residential areas served by private septic systems in the Millers Creek watershed are within the jurisdiction of Ann Arbor Township.

Stream Enhancement

There are two modern paradigms associated with stream improvements today. The second suggests that improvements should be based on controlling impacts to the extent practical and then allowing the stream to adjust to a new set of environmental conditions. This is a more passive approach to stream enhancement that is based on the theory of dynamic equilibrium. That is, one expects a stream channel to adjust until it reaches a certain level of stability under the new environmental conditions. The first paradigm suggests that improvement should be based on controlling impacts to the extent practical, designing stream enhancements to the new set of environmental conditions, and then actively changing the stream channel to establish an expected and/or desired condition. This paradigm is a more active approach that is also based on the theory of dynamic equilibrium, but it attempts to predict the changes that will take place and then create the new condition that is expected to occur in response to the new environmental conditions.

Both paradigms incorporate, to some extent, the notion that urban streams cannot be restored, only improved and enhanced, due to the level of disturbance associated with heavily urbanized areas like Millers Creek. The scientific literature supports this general understanding quite well. The most important aspects for paradigm selection are stream corridor space restrictions and cost, and their forecast benefits.

The two paradigms differ in their implementation strategies that are designed to achieve a desired condition. There are pros and cons to both approaches. For example, the more passive approach involves less risk of failure but requires more time, and patience, to achieve the desired improvements. On the other hand, the more active approach involves more risk of failure but less time to achieve the desired improvements (assuming the efforts are successful).

The Millers Creek Implementation Plan proposes a mix of the two approaches. For example, eroding stream banks that threaten infrastructure should be dealt with regardless of the outcomes of other activities or the anticipated changes that lie ahead. In other cases, it may be desirable to accept some risk in order to hasten the improvement process through physical channel alterations (e.g., fish habitat enhancements). Watershed improvement opportunities that fall within this category should be dealt with on a case-by-case basis as a matter of priority. As appropriate, the activities can be evaluated within the context of the implementation process to determine the appropriate time to implement them. Such decisions should be based on the prevailing philosophies (within the steering body) regarding stream enhancements, public expectations, regulatory pressures, acceptable levels of risk, monitoring results, and available funding. This plan provides a prioritized list of improvements that prioritizes hydrologic control activities first, critical infrastructure needs, including eroding streambanks that threaten infrastructure, second and active channel enhancement last. Refer to Chapter 7 for prioritization and estimated costs.

Land Conservation
The conservation of open space and preservation of natural habitats is important to protecting watersheds and for fostering meaningful personal experience with our natural surroundings. It is especially important in disturbed watersheds where open space and natural habitats have been reduced to small portions of the overall watershed area. Areas contiguous to and part of the corridor are vitally important. Furthermore, natural areas such as forests provide irreplaceable hydrologic functions and wildlife habitat. Millers Creek was most forested prior to European settlement. Logging and farming practices reduced forest cover considerably. Urbanization of the Millers Creek watershed has left only fragments of forests and intact river corridors. Today, approximately 16% of the Millers Creek watershed is forested. The remaining open spaces in the Millers Creek watershed continue to provide critical hydrologic functions and wildlife habitat. Continued pressure to develop the open space will further contribute to storm water and water quality management problems despite efforts over the next ten years to improve the watershed. Although preserving land is preferable, land development is not precluded. In some cases, development will be necessary. Through better site design and sustainable development practices, the impacts of additional development in Millers Creek can be minimized. Natural feature setbacks can be used to protect the important vegetated buffers and development footprints can be minimized to limit natural feature impacts (e.g., tree clearing), and small, distributed BMPs located close to runoff sources enhance treatment and infiltration (where feasible). This type of land development approach is often referred to as "low-impact development." Land use ordinances are an important tool for implementing such land conservation practices.

Soil Erosion and Sedimentation Control (SESC)
The primary source of erosion and sedimentation in developing watersheds is construction sites. Soil erosion and sedimentation is controlled through state legislation and implemented at the local level. In Millers Creek, it is implemented primarily by the City of Ann Arbor. SESC programs are important and need adequate funding and staff. Inspection and enforcement are important and will ensure that SESC practices are properly implemented as designed and maintained in a functional manner. Improving inspection and enforcement capabilities will greatly increase the effectiveness of the SESC program for Millers Creek. The Millers Creek Improvement Plan recommends additional staffing and funding to support inspection and enforcement efforts.

Native Landscape Restoration
Manicured open space habitats or areas where natural habitats have been lost can be restored. Open space in City parks, housing complexes, commercial and industrial properties, and along Millers Creek contain opportunities to establish forests and prairies. Such native species would replace managed turf grass with communities that provide important wildlife habitat and hydrologic functions. These native plant communities reduce storm water volumes by intercepting precipitation, increasing evaporation, and increasing infiltration.

<u>Reforestation</u>
Forested communities are important for storing precipitation on the landscape. Leaf litter and organic matter on the forest floor act like a sponge while the leaf and bark surface area intercepts rainwater. Reforestation also reduces consumptive turf grass management practices. Reforestation differs from tree planting in that it entails high

density planting and abandonment of managed turf grasses to allow the development of a natural forest floor community with its inherent functions.

Stream Buffers

The vegetation along the stream corridor is important to overall stream health. It provides many functions including pollutant filtering, stream shading, wildlife habitat, flow control, sediment trapping and soil stabilization. The stream corridor should be vegetated to the waters edge with native vegetation. Trees and shrubs are preferred on stream banks for shading and erosion control. Vegetated stream buffers should be established along Millers Creek where development has encroached and natural vegetation removed. The buffer should be as wide as site constraints and land management requirements allow.

Native Prairie

Prairies are similar to forests in many functional respects but are dominated by grasses and forbs rather than woody species. Mature prairies can be established over much shorter time frames than mature forests. Consequently, the benefits from their functional values are realized much sooner.

Native Vegetation Management

While the natural areas in the Millers Creek watershed provide a host of important wildlife habitat functions, those functions can be negatively impacted by the presence of invasive plant species. Some invasive plant species displace native species and decrease forest understory productivity. Many of the natural areas in the Millers Creek watershed have invasive plant species that are impacting the functional values of those natural features. Controlling the invasive plant species and encouraging propagation of native species will improve the value of natural features in the watershed.

7. ALTERNATIVES EVALUATION

Five alternative scenarios were developed to evaluate the range of benefits the key improvement recommendations could achieve. The alternatives and their analysis are structured as a series of incremental improvements. Each alternative scenario builds upon the cumulative improvements recommended in all previous scenario(s). For example, Alternative 1 looks at the impacts on a completely built-out (developed) watershed. Alternative 2 considers the impacts of reforestation and drain disconnects on build-out conditions. The first four alternative scenarios were designed to provide increasing levels of flow and water quality control with structural controls. The last alternative examined the use of non-structural water quality controls and the impact of stream bed grade changes on erosion potential. The rationale for approaching controls as incremental improvements was based on five key assumptions:

1. The primary problem for the poor in-stream habitat, widening banks, deepening channel bed, and impoverished macroinvertebrate population is extreme hydrologic disruption by development and lack of comprehensive storm water management measures in the watershed.

2. Any recommendations for stream bed and stream bank restoration should be made and analyzed after understanding the impact of other recommendations aimed at stabilizing hydrology.

3. Conditions in the creek and watershed are so extreme that achieving some semblance of earlier pre-built out conditions is effectively impossible. Therefore, there is no effective limit on the number of BMPs that could be installed in an attempt to recover earlier conditions.

4. Establishing the alternatives as side-by-side comparisons of two or more sets of completely different choices would not be an efficient process. Structuring the alternative scenarios as a set of incremental improvements establishes both the relative improvement effectiveness of different classes of improvements and the overall effectiveness of all the alternatives at the same time.

5. Due to the extreme conditions, some reliance has to be placed upon the capacity of the stream to recover a flow and sediment transport balance on its own.

An important provision of this analysis is that although some of the recommended improvements were not analyzed, that does not imply they would provide no benefit to the creek. On the contrary, every recommended improvement in this plan would have some positive impact. Some representative reasons that certain recommended improvements were not included in the modeled alternatives analysis include:

1. No existing quantitative basis for judging impacts is available; e.g., the impacts of public education on fertilizer use.

2. The number of deployment sites appears to be limited and therefore did not warrant analysis effort; e.g., bioretention areas appear to be limited by the predominance of clay loam soils in the watershed.

3. In addition, some assumptions of existing conditions are very conservative. For instance, when estimating a soil's infiltration rate, the limiting soil layer value in the

column was assumed. Because of this assumption, a significant area of coverage by a top layer of hydrologic soil type B was re-classified because a lower soil layer had a lower infiltration rate. We recommend that each site's soils should be field tested before definitively ruling out the use of infiltrative practices.

4. Although some literature exists on impacts, it is either limited, done in another region or both; and, acceptance of these impacts has not been proven locally; e.g., planting native vegetation increases localized infiltration rates with time.

5. Although there are a high number of opportunity areas, density of application within the opportunity area is low; for example, low density tree planting areas (as opposed to reforestation areas) such as parking lot islands.

Undoubtedly, opportunities not described in this plan that can benefit the watershed will also arise. Before implementation of improvements not specifically identified in this plan, each proposed improvement should be judged on how it meets the spirit and intent of this plan.

7.1 Alternative Modeling Scenarios

The five alternative modeling scenarios created to judge the success of the recommended improvements for meeting flow and water quality objectives are:

1. Build-out conditions
2. Reforestation and Drain Disconnects
3. New Storm Water Detention and Detention Pond Retrofits
4. Additional Storm Water Detention, Detention Pond Retrofits, Proprietary Water Quality BMPs and Huron HS Sediment Trap
5. Street sweeping; No-Phosphorus Fertilizer Ordinance; Construct boulder drops at the 84-inch culvert at the Hubbard site and at the outlet of the curved culvert above the Glazier site

Build-out land use is shown in **Figure 7.1**. Locations of the individual modeled improvements are shown in **Figure 7.2.** The alternatives analysis was structured as a series of incremental improvements. Each alternative built upon the cumulative improvements recommended in all previous scenario(s). The hydrologic and hydraulic events modeled included the first flush, 1-year, 2-year, 5-year, 10-year and 100-year design events.

For the water quality analysis, only the first flush, 2-year and 10-year events were simulated. Only two kinds of pollutant concentration removal mechanisms were simulated in the water quality model: 1) removal of total suspended solids (TSS) and total phosphorus by settling, and assumed removal rates by proprietary BMPs. Other removal mechanisms, such as adsorption or biological uptake were not quantified. This approach should yield a conservative estimate of TSS and TP removals.

Descriptions of the alternative scenario modeling techniques and assumptions are summarized below.

Alternative 1: Build-out Conditions

The future development projections for undeveloped parcels in the watershed were based on the City of Ann Arbor's Northeast Area Plan (NAP, 2003). The NAP identifies these parcels as Study Sites and provides recommendations for future built-out land use. These recommendations extend to the UM North Campus as well. Because the UM Master Plan was undergoing revision during this project, only the NAP recommendations were used to estimate build-out conditions for sites on UM property. In addition, it was assumed that any re-development within the campus would provide storm water management that would meet or exceed current conditions. Build-out recommendations from the NAP include areas of open space conservation, re-development areas and conversion of open space to new Ann Arbor parkland, new residential, new commercial and new industrial developments.

In areas recommended for conservation or areas of re-development, it was assumed that the land use, particularly in terms of directly connected impervious area (DCIA), was effectively unchanged. In areas where new low and medium density residential housing was recommended, it was assumed that the build-out condition would be reached, so to speak, one house at a time. In these areas, changes to the existing conditions model entailed increasing the DCIA percentage of the affected subwatershed. The increase in DCIA was based on estimates of DCIA from existing, comparable land uses.

For proposed future high-density residential housing and commercial/industrial development in the watershed, we assumed that the Washtenaw County Drain Commissioner's (WCDC) requirements for on-site storm water detention would have to be met. For these proposed development areas, a DCIA based on similar existing developments in the watershed was assumed, and detention pond and outlet structure were sized per WCDC rules and standards.

Pond and outlet sizing, and routing of runoff into and out of the proposed pond, was calculated outside of SWMM using a custom pond model (See **Appendix A**). The pond model calculates runoff using a curve number approach, then uses an iterative technique to determine pond and outlet sizes necessary to meet WCDC rules and standards. The model then uses a numeric technique (a 4^{th} order Runge-Kutta calculation) to route the runoff inflows into and out of the pond. Output from the pond model was used as input to the SWMM EXTRAN model for the alternatives analysis. This pond model, and the output used in this analysis, is included as an appendix to this report. Usually, the proposed development was only a portion of the land within a given subwatershed. Therefore, the drainage area associated with each proposed build-out development site was subtracted from the total subwatershed area in the SWMM RUNOFF model so that site runoff was not double-counted.

Alternative 2: Reforestation and Drain Disconnects

To account for the recommended reforestation efforts, the runoff parameter "pervious storage" was modified. When pervious area is occupied by forest instead of lawn, a much greater amount of rainfall is intercepted by tree and understory branches and trunks and stored in the more variable topography created by the roots, depressions and fallen timber in a forest. For instance, natural forests' canopy interception ranges from 15% to 40% of annual precipitation in conifer stands and from 10% to 20% in hardwood stands (Zinke, 1967). Experiments on a lone oak tree found interception losses of 50% and 20% respectively for rainfall depths of 0.18 inches and 0.59 inches (Xiao, et al., 2000). For this alternative, only the pervious storage for the area of recommended reforestation within a subwatershed was changed to 0.5 inches.

The University of Michigan has two high-density, family-housing developments in the Millers Creek Watershed. Half the roof drains from these developments are connected directly to storm drains that empty into Millers Creek. By disconnecting these drains and storing the water on-site via rain gardens and/or rain barrels, U of M would effectively decrease the impervious area for those subwatersheds. Assuming the roof drains would be disconnected, the roof area for each development was subtracted from the total impervious area of their respective subwatersheds.

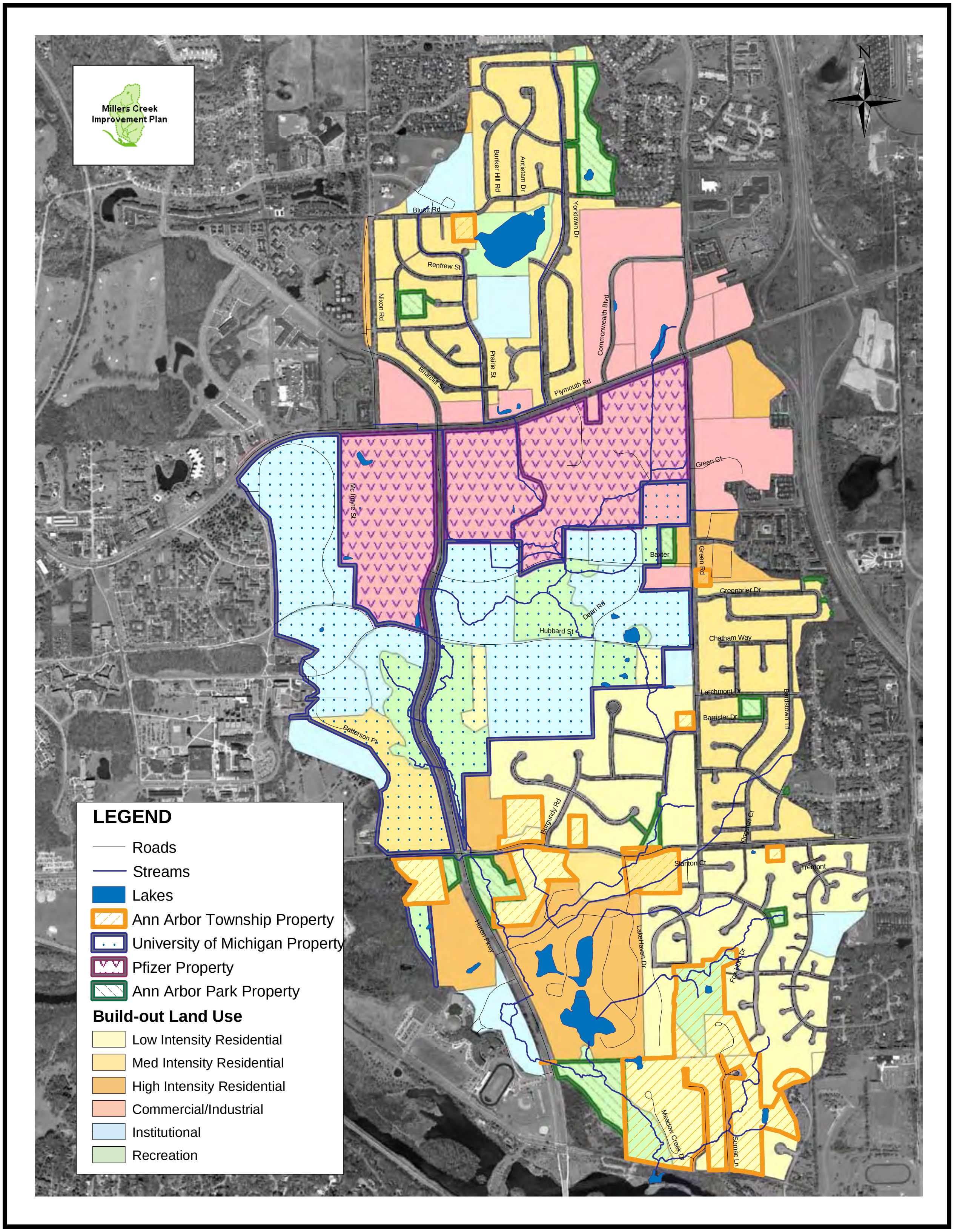

Figure 7.1 Assumed Land Use for Built-Out Conditions

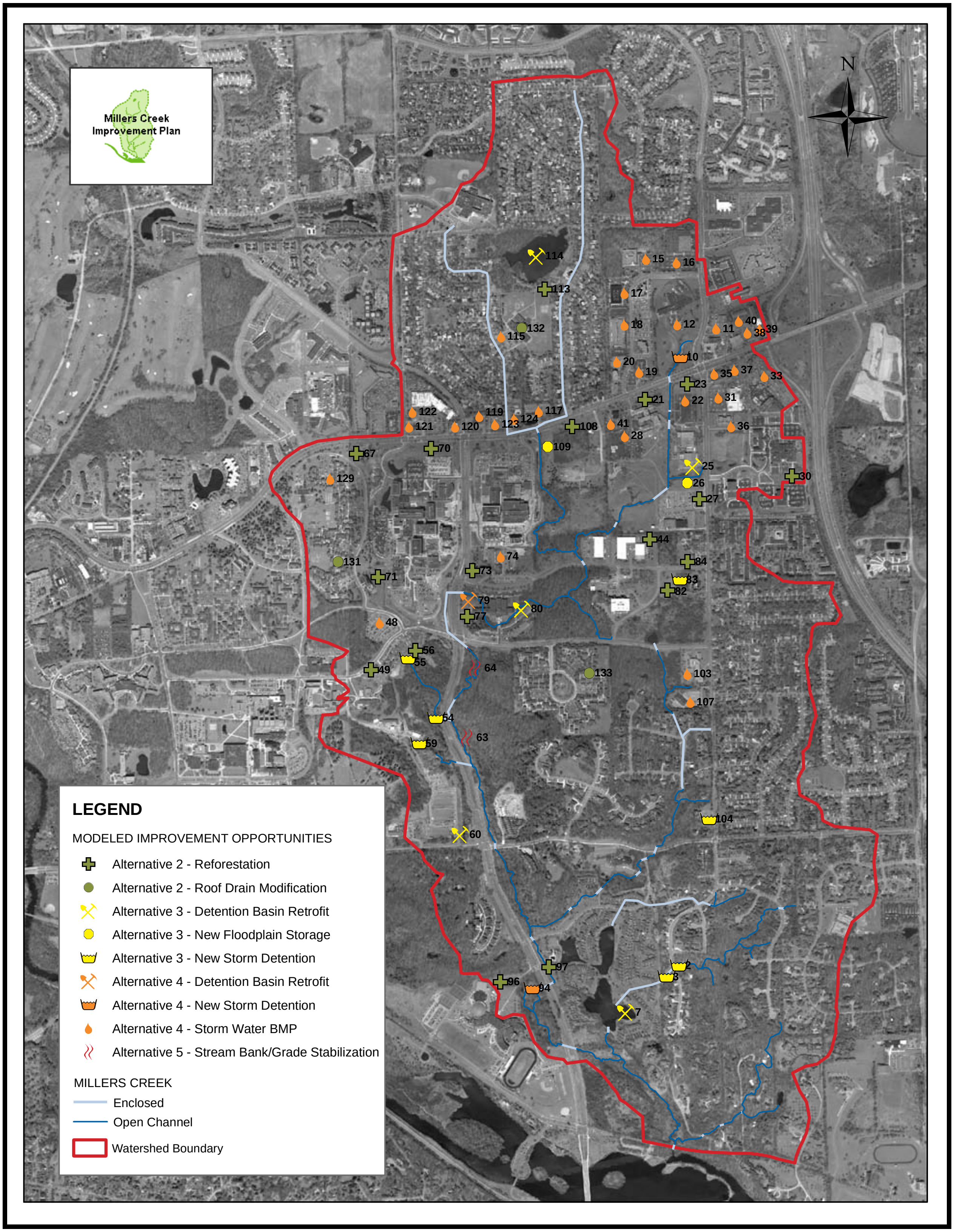

Figure 7.2 Locations of the Individual Recommended Improvements for Modeling Scenarios 2-5

Alternative 3 - New Storm Detention, Regional Off-Line Detention and Pond Retrofits

In order to simulate all of the detention recommendations in the model, several different techniques were utilized. The first involved two sites that currently have no detention basins but have appropriate areas for on-site detention. These two sites are located in the portion of the watershed that was not directly represented in SWMM, meaning that there were no direct links or nodes that could be modified in the model. Consequently, the pond model was used to size appropriate detention basins and create outflow hydrographs that were entered directly into the closest node in the hydraulic mode of SWMM (EXTRAN). As in Alternative 1, the corresponding areas were subtracted from their respective subwatershed areas in the SWMM RUNOFF model to avoid double-counting the drainage areas.

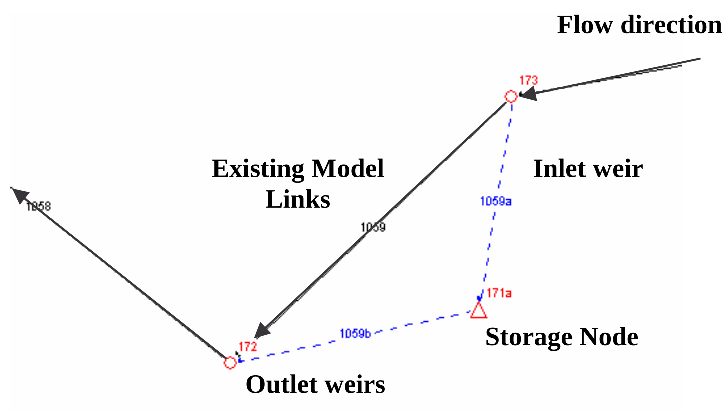

Figure 7.3 SWMM Schematic of Offline Detention

Four locations were recommended for off-line regional detention basins to reduce peak flows. Conceptually, these basins can be visualized as created wetland basins that have engineered inlet and outlet weirs to re-direct stream flows into and out of these basins during high flows. As shown in **Figure 7.3**, these basins were modeled as a storage node and connected to the model channel with inlet and outlet weirs. When the water level in the stream rises to a certain elevation during a storm event, water will begin to flow into the offline detention pond from the stream channel. As the water level continues to rise, water will exit the pond downstream and flow back into the channel. For this level of analysis, the inlet weirs for all four off-line basins were set to overflow into the basin at or above the first flush storm event (0.5 inches of rain in 6 hours).

Recommended detention pond retrofits were simulated in five areas where water is already detained to varying degrees. The retrofits included using outlet structures comprised of a row of orifices at first flush event water elevations in addition to a 3-foot diameter standpipe overflow, which was simulated in the model with a weir. The addition of the outlet structure allows storm water to back up to a greater extent, and thus a much greater volume of water is detained for a given storm event.

Additional recommendations were modeled under Alternative 3. The University of Michigan recently constructed a retention pond for their maintenance area on the west side of the watershed. To account for this in the model, the drainage area for the new pond was subtracted from the total subwatershed area, effectively removing that water volume from the system altogether. Similarly, when the Millers Creek project began, the Geddes Lakes outlet structure was not built to detain smaller rainfall events. In Summer 2003, the structure was altered to achieve extended detention in the lakes. The storage node in the SWMM model for Geddes Lakes was modified to reflect the recent outlet structure retrofit.

Finally, Alternative 3 included changes in how Thurston Pond was modeled. Thurston Pond originally proved difficult to model due to conflicting records on the elevations of the inlet and outlet structures. In order to more correctly simulate the function of the pond, additional survey points were taken, and the updated elevations were incorporated into the SWMM model. In addition, a storm sewer pipe carrying a portion of the runoff from Clague Middle School that currently bypasses the Thurston Pond outlet during most rain events was turned off in the model, enabling approximately 30% of the school's runoff to flow directly into Thurston Pond.

Alternative 4 - Additional Storm Detention, Detention Pond Retrofits and Sediment Traps
Alternative 4 primarily analyzed the improvements of recommended water quality improvements. These improvements include the installation of 33 individual proprietary stormwater BMPs, such as the *Stormceptor* by Rinker Materials. The units were preliminarily sized for an average annual TSS removal of 80%. Removals for the first flush water quality event was assumed to be 100%; 80% for the two-year recurrence interval design storm event and 60% for the 10-year recurrence interval design storm.

Four other structure recommendations were incorporated into the SWMM model.

1. An additional offline detention pond was added at the UM Administration Building, just upstream of the culvert carrying flow under Huron Parkway and under the Pfizer mitigation wetland, using the method described under Alternative 3.

2. An outlet control structure was simulated just downstream from the Ave Maria wetland to detain additional runoff. Part of the runoff flowing through the storm sewer in Commonwealth Boulevard was also re-directed into this retrofit basin.

3. The Georgetown Boulevard inlet for Thurston Pond, which currently receives storm water only during big rain events, was increased in diameter to handle a greater amount of the overflow runoff from the Georgetown Boulevard storm sewer.

4. An energy dissipation box/sediment trap, similar to the one upstream of the Glazier sampling site, was modeled in the Huron High School reach of Millers Creek.

Alternative 5 – Boulder drops, street sweeping and enactment of no-phosphorus fertilizer ordinance
For alternative 5, boulder drops, serving as energy dissipation structures were simulated at the outlet of the 84-inch culvert at the Hubbard site and at the outlet of the curved culvert above the Glazier site.

In addition, based on two field and modeling analyses of runoff TSS loads and removals (Sutherland and Jelen, 2003 and TetraTechMPS, 2001), a removal rate was assumed for recommended street sweeping procedures and applied directly to calculated TSS loads.

A projected TP mass removal rate was also applied to calculated loads based on a recent field experiment looking at the impacts of banning the use of phosphorus in fertilizers (University of Minnesota, Duluth, Natural Resources Research Institute, et al., 2003).

7.2 Results
Quantitative assessment measures used to gauge the success of the alternative improvements included:

1. Peak flow reduction, over all design recurrence interval storm events,
2. Peak shear stress reduction, over all design recurrence interval storm events,
3. Peak velocity reduction, over all design recurrence interval storm events,
4. Peak water surface elevation reduction, over all design recurrence interval storm events
5. Total reduction of total suspended solids (TSS) loads, for the first flush, 2-year and 10-year design recurrence interval storm events and
6. Total reduction of total phosphorus (TP) loads for the first flush, 2-year and 10-year design recurrence interval storm events

Peak Flow Reductions
The peak flow reduction goals were aimed at the bankfull events. The bankfull event in most reaches was defined as the 2-year design recurrence interval event. In the reaches where the stream still reaches its floodplain, the bankfull event was somewhere at or above the 1-year design recurrence interval event. Peak flow reductions for the 1-year design recurrence interval event ranged between 37% at Geddes to 54% at Glazier and Hubbard. Peak flow reductions for the 2-year design recurrence interval event ranged between 35% at Plymouth to 42% at Meadows (**Figure 7.4**). By reducing the peak flows 40% to 50% for the storm events doing the most work to shape the channel, the peak flow reduction goals for the project were met. Note that these reductions are for alternative four and were designed to be conservative estimates of reductions. These results are conservative because all model assumptions tended to be conservative, and not every possible improvement, as noted above, was modeled.

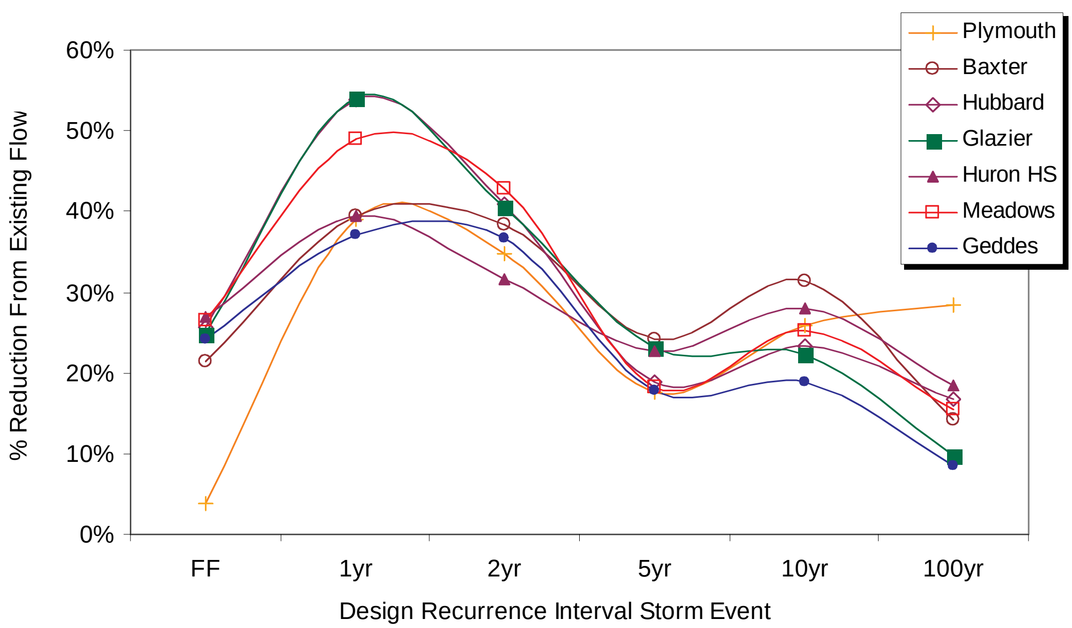

Figure 7.4 Comparison of Peak Flow Reductions between Existing Conditions and Alternative 4

Peak Shear Stress Reductions
In most sections, the largest reduction in peak shear stress is about 20% (**Figure 7.5**). Peak flow reductions do not correspond in a one-to-one fashion to peak velocity or peak shear stress reductions. Shear stress is a function of the channel's hydraulic radius and channel bed slope. The hydraulic radius is the ratio of the area of flow to the wetted perimeter across a channel

section. The wetted perimeter is the length across the section that is contact with the moving water. It is this contact region that induces the primary energy loss. The hydraulic radius changes as the flow depth changes, and flow depth changes in proportion to flow raised to the 3/5^{ths} power.

However, in the reach between Hubbard and Glazier below the baffle box, we have specified stream bed stabilization (grade control) measures to decrease the bed slope. This results in a roughly 40% reduction in shear stress in this section – a significant improvement. Although this reduction is not quite enough to meet bed stabilization goals, we believe the channel in time will reach an equilibrium that will stabilize the channel. The bed stabilization improvements should hasten the stability and help stabilize the eroding stream banks in this area as well.

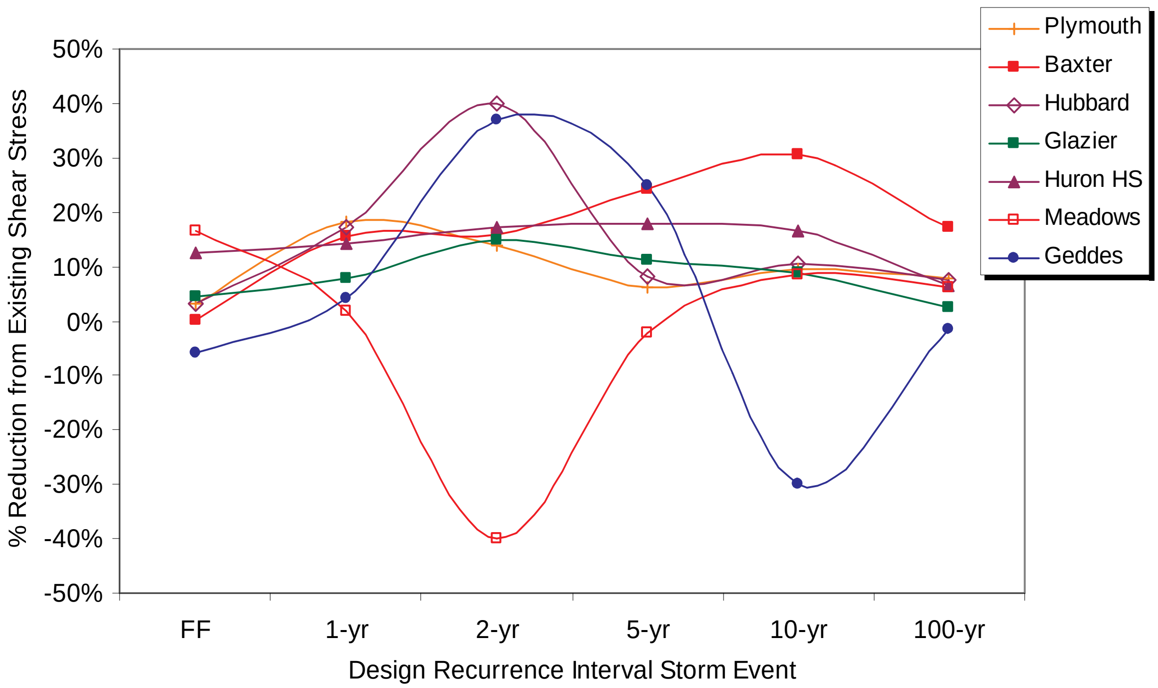

Figure 7.5 Comparison of Peak Shear Stress Reductions between Existing Conditions and Alternative Five (calculated shear stress is the average across the bed)

The negative reductions in shear stress at Meadows and Geddes indicate that the post-improvements shear stress will actually increase in these areas. This is because the lowered peak flows translate into less overbank flow. Overbank flows significantly decrease energy due to friction of moving water downstream. By decreasing the frequency and depth of overbank flows, more water is concentrated at or just below bankfull. Bankfull flow is typically the most efficient flow. It carries the most water per unit area of the channel section and therefore creates the most shear stress per unit area. This reduction in bankfull flows should help to move sediment through the section and forestall the stream's efforts to build up its base level (and slow the filling of the culvert under Huron Parkway with sediment deposits).

Peak Velocity Reductions

Average cross-section velocity is the flow across the section divided by the total area of flow at that section. As flow is reduced, area across the section is reduced. As shown previously in **Chapter 4**, for most cross sections there is little chance for achieving velocity reductions of magnitude similar to peak flow reductions once the 1-year design recurrence interval flows are exceeded (See **Figure 7.6**). Additional peak velocity reductions were achieved in the reach between Hubbard and Glazier by the use of grade control structures.

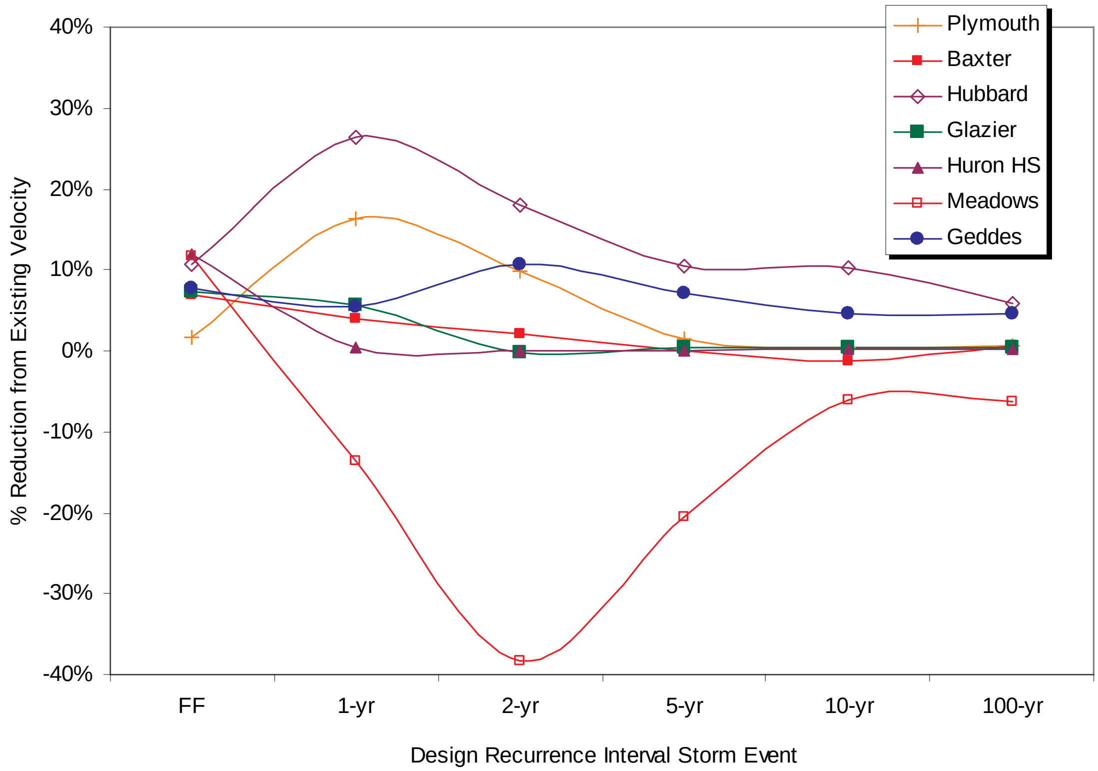

Figure 7.6 Comparison of Peak Velocity Reductions between Existing Conditions and Alternative Five (calculated velocity is the average across the channel)

Once again the results show some negative reductions in velocity but only at the Meadows site. These higher velocities are also the result of lower peak flows resulting in more water in the channel and less flow going overbank.

Total Suspended Solids Reductions
Figure 7.7 shows the cumulative reductions for Alternatives 1-4 and in addition, shows the impact of increasing the frequency and manner of street sweeping. The purchase of a high efficiency or regenerative air sweeping street sweeper is recommended. These are very efficient units and also do an excellent job removing fine particles. Many pollutants are typically attached to and transported via fine particles.

TSS reductions range between 10-15% for alternative two and 27-35% for alternative four. Based on analyses by Sutherland and Jelen (2003), by increasing street sweeping frequency from semi-annually to quarterly and using a high efficiency sweeper, reductions can be increased by approximately another 13%. In a pilot study in Jackson, Michigan, runoff TSS removals reached 50% with monthly high efficiency sweeping and catch basin cleaning (TetraTechMPS, 2001). Although this recommendation would likely necessitate hiring new City personnel, in the long run, source control is the most cost-effective storm water management option. This is particularly clear for control of phosphorus (see next section below). In addition, the costs and benefits associated with frequent high efficiency sweeping should be spread among all the City watersheds and not just Millers Creek.

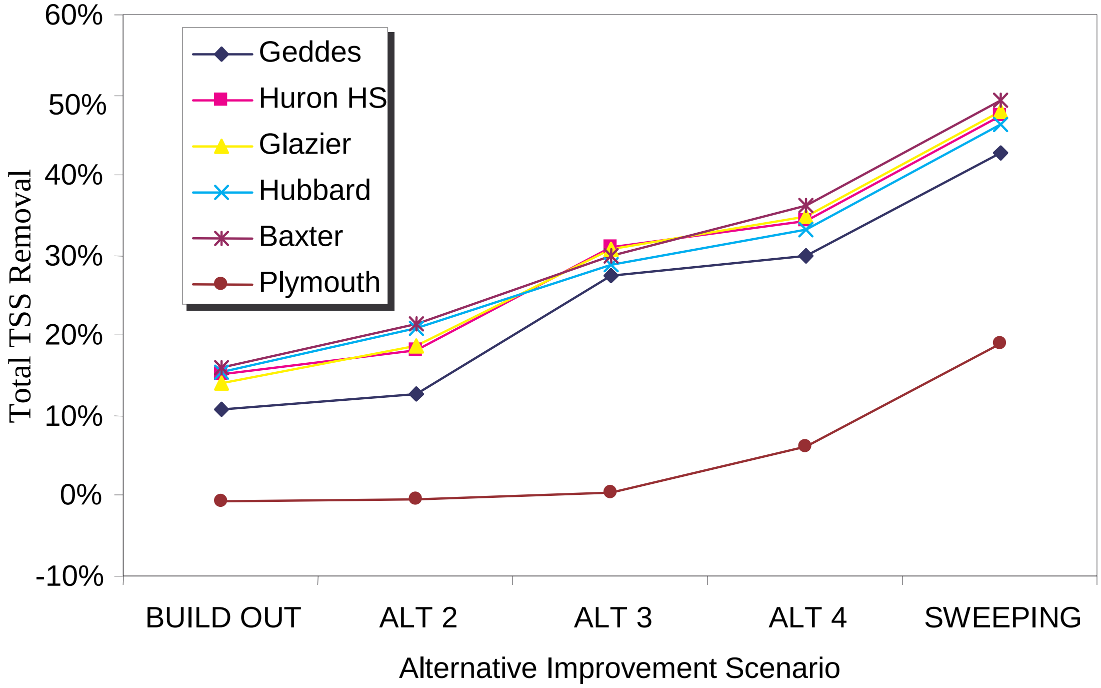

Figure 7.7 Calculated Total Suspended Solids Removals for 2-Year Design Recurrence Interval Storm Event

Total Phosphorus Reductions

Figure 7.8 shows the cumulative reductions for Alternatives 1-4 and the impact of passing and enforcing a no-phosphorus fertilizer ordinance in Ann Arbor, or at the state level. The impacts of a no-phosphorus fertilizer ordinance were based on draft results from a new, detailed, paired watershed study in Minnesota. The study compares water quality from one watershed with an imposed phosphorus fertilizer ban against a control watershed (with no ban). Over the summer of 2001, the watershed with the phosphorus ban recorded a 78% increase in phosphorus mass reduction over the control watershed (University of Minnesota, Duluth, Natural Resources Research Institute, et al., 2003. Lake Access Empact Metro Project. Lawn Fertilizer Project. http://www.lakeaccess.org/lakedata/lawnfertilizer/recentresults.htm).

Although the modeled reductions are less than the project goal of 50%, the Jackson, Michigan and Minnesota pilot studies suggest that street sweeping and phosphorus-free fertilizers can make up any shortfall necessary to achieve the target reductions.

The study utilized accepted water quality sampling and analysis protocol and analyzed mass results over multiple events. The paired watersheds appear to be identical in every way except for the phosphorus ban. These results emphasize the point that source control is ultimately the most efficient and most cost-effective tool to protect water quality. The level of phosphorus control after a ban in this area was assumed to be at the 50% level. In this case, merely implementing and enforcing a phosphorus ban would provide impacts that exceed all the calculated improvements from the modeled alternatives combined. Even assuming the mass loss achievements were half of the measured improvements in the Minnesota project, a phosphorus ban would still exceed the calculated improvements for the combined alternatives analysis.

However, as noted above, the alternatives analysis treated the benefits of infiltration very conservatively and did not assume removals via this route. In addition, dissolved phosphorus uptake was also not accounted for as a loss mechanism in this analysis, another very conservative assumption. Plant uptake is particularly high during the growing season, the critical period for the phosphorus TMDL, and would contribute to overall phosphorus losses following implementation.

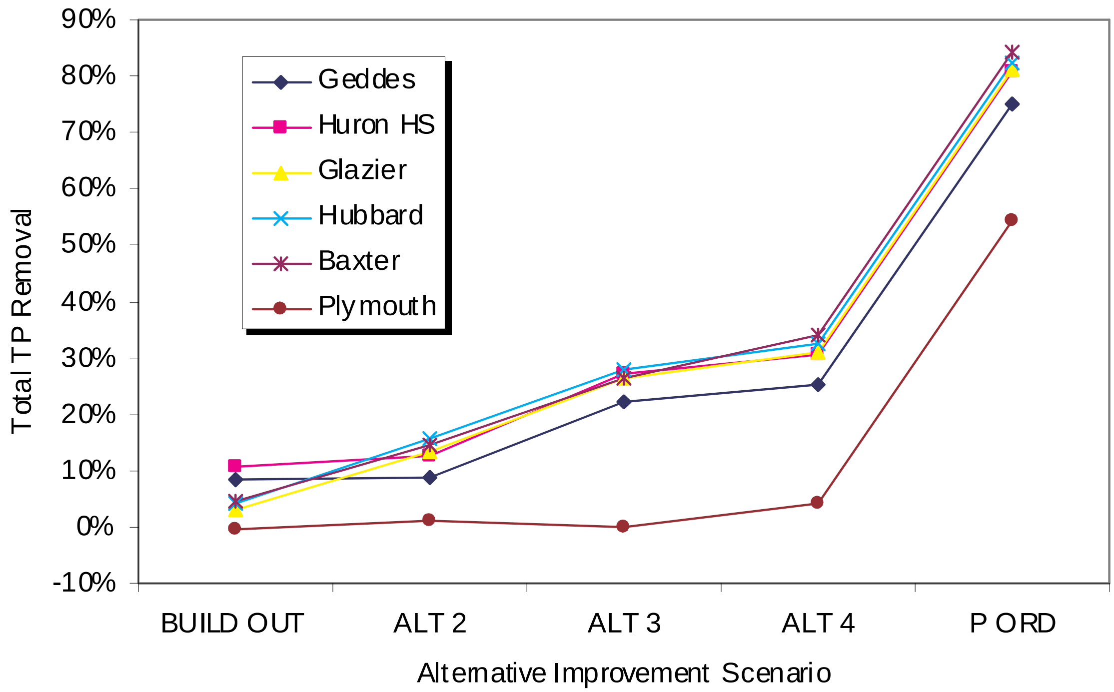

Figure 7.8 Calculated Total Phosphorus Removals for 2-Year Design Recurrence Interval Storm Event

8. IMPROVEMENT PLAN IMPLEMENTATION

The Millers Creek Improvement Plan is an effort to improve the water quality, habitat, and recreational value of Millers Creek and Middle Huron River through resource protection, source control, and pollution prevention activities. The implementation approach described below is intended to leverage existing Huron River initiatives and available funding sources to ensure that the Millers Creek Improvement Plan is effectively and efficiently implemented.

Implementing the Millers Watershed Improvement Plan will require the concerted efforts of the City of Ann Arbor, Washtenaw County, Ann Arbor Township, and the University of Michigan, the four regulated storm water communities under Phase I and II NPDES permits. These communities are responsible for ensuring that water quality and water use impairments are addressed. However, a committed public-private-corporate partnership, much like the one that initiated this project, will ultimately be the key to success. All individual landowners, institutions, industries, business owners, and local units of governments have a stake in the improvement of Millers Creek, and all can contribute to the successful implementation of the plan.

8.1 ROLE OF MCAT

The Millers Creek Action Team (MCAT) is an informal partnership that formed with the purpose of completing the Millers Creek Improvement Plan. Its members include representatives from each of the stakeholder groups mentioned above, among others. The MCAT has been effective and successful in steering the Millers Creek study and fostering development of the improvement plan.

Once the Millers Creek Improvement Plan is complete, MCAT will have met its original purpose. However, the members want to remain active through the implementation process. MCAT may be slightly restructured and will adopt a new purpose and common goal – ensuring the successful implementation of the plan. While the explicit roles of the members and group at large is still in flux, MCAT will likely play a key role in directing the implementation process. This partnership of stakeholders will be instrumental in maintaining project momentum, developing accountability, encouraging compliance, fostering stewardship, involving and educating the public, and providing project oversight.

8.2 THE MIDDLE HURON INITIATIVE

Many of the existing MCAT members are already partners in the Middle Huron Initiative and currently support or serve an implementation role for that initiative. Regardless of how the Millers Creek Improvement Plan will be implemented, it will be an integral part of the Middle Huron Initiative. Currently, subwatershed management plans are complete and approved for the Malletts Creek, Ford Lake, Fleming Creek and the Mill Creek subwatersheds. Subwatershed management plans are underway for the Allens Creek, Belleville Lake, and Traver Creek subwatersheds. Completing watershed management plans for all of the sub-basins has been supported by the Middle Huron Initiative because reducing runoff and pollutants from these sub-basins is fundamental to meeting the overall goals of the Middle Huron Initiative – reducing phosphorus and *E. coli* bacteria loads. The Millers Creek Improvement Plan is now complete and will be adopted into the Middle Huron watershed plan. The year 2000 version of the "Watershed Plan for the Huron River in the Ann Arbor – Ypsilanti Metropolitan Area" will be updated to incorporate the recommendations for Millers Creek. The updated plan will be submitted to the Michigan Department of Environmental Quality for approval as a certified management plan, reflecting recommendations of the Millers Creek Improvement Plan. This process will make the Millers Creek watershed eligible for State non-point source funding (e.g., Clean Michigan Initiative and Section 319).

8.3 IMPLEMENTATION ACTIVITIES, SCHEDULE AND COSTS

The proposed ten-year schedule for the Millers Creek Improvement Plan begins in 2004. The budget estimate for the plan has been divided into 45 activities spread out over ten years (See **Table 8.1.** Cost back-up is included in **Appendix N**). These 45 activities summarize the 112 different improvement opportunities previously identified and some of the representative, on-going activities of the Middle Huron Initiative, phosphorus and *E. coli* TMDL implementation plans, and various stewardship programs. The recommended, site-specific BMPs are summarized in **Appendix L** by key stakeholder and drainage area. The stakeholders are identified based on property ownership. Sixteen focus areas (See **Figure 8.1**) have been outlined to help organize the main structural implementation activities. Descriptions of the focus areas and activities follow in Section 8.3.2. The Middle Huron Initiative, ongoing TMDL implementation activities, and recommended monitoring activities are described in more detail in Section 8.3.2.

8.3.1 Costs and Schedule

Table 8.1 summarizes the estimated costs, in 2003 dollars, and the recommended implementation schedule for the proposed activities. The first primary activity is to develop the county drainage district for Millers Creek. This cost will kick in after one or more of the major stakeholders petition the Washtenaw County Drain Commissioner for the creation of the drainage district. It is expected that some of the typical costs for developing the drainage district will be offset by the data and analysis already provided by this study.

New detention basin and off-line floodplain storage costs are based on City of Ann Arbor total calculated cost of $12 per cubic foot of detention storage (Hupy, 2003). This includes engineering and construction costs. The water quality BMP costs were estimated assuming installation of a Stormceptor unit (only as a basis for cost, not as the required BMP for installation). Installation costs were considered to be equivalent to the cost of the BMP unit, while engineering and the contingency are a combined 30% of the BMP and installation cost. Other structural BMP costs were estimated assuming a construction/installation cost plus 30% for engineering and contingencies. Due to the large uncertainty associated with property values, costs for easements and property purchase were not included with any of the BMP construction cost estimates.

Some on-going activities, such as the Middle Huron Initiative and passing/enforcing a new fertilizer ordinance (or state law) are included in the cost and schedule table with no associated costs. This is to emphasize that these activities are critical to the Millers Creek Improvement Plan, but have and will continue to be pursued by stakeholders without the need for additional funding specifically set aside for this project.

Other activities, such as upgrading City of Ann Arbor street sweeping equipment and adding staff for soil erosion and soil control enforcement, have been estimated as approximately $1/7^{th}$ of the total cost to the city. This is to reflect the fact that for both of these activities, the additional staff and capitol expenditures will benefit, and the costs should therefore be shouldered by, the entire city.

An annual average maintenance cost, assessed as a 3% of estimated capitol costs was included for new detention/floodplain basins and BMPs that will require sediment removal. This cost is based on cumulative annual needs and reaches a total annual maximum on the tenth year of the plan of $317,000.
Assuming that all the WCDC projects, except the illicit discharge elimination plan, are financed with loans having a ten-year term and an annual interest rate of 6%, the WCDC would pay an

additional $2.2 million in interest on $7.3 million worth of work. The interest cost is not included in Table 8.1 because the interest payments would essentially start in Year 2 of the implementation schedule and continue for seven years beyond the end of the 10-year plan. The loan repayment schedule is included in **Appendix N**.

8.3.2 Implementation Focus Areas

This section includes a summary of improvement "focus areas." These are areas of critical improvement recommendations grouped together by spatial proximity to help focus implementation activities (See **Figure 8.1**). These focus areas represent a subset of all recommended improvement opportunities.

Focus Area #1

<u>Thurston Pond</u>

a) Currently, Clague Middle School has two storm sewer outlets, one of which discharges to a manhole in front of the school. The lower outlet from this manhole discharges to storm sewer on Renfrew Street. The other, higher (overflow) outlet discharges to Thurston Pond. An opportunity exists to disconnect the Clague storm sewer connection to Renfrew Street at the manhole, install a Stormceptor or equivalent structural BMP and re-direct all treated storm water (not just the overflow) into Thurston Pond.
b) The sump pump disconnect program has disconnected several homes immediately adjacent to Thurston Pond and re-directed the sump pump discharge to Thurston Pond. In addition, at least two of the sump pumps appear to be tapping a spring. Recorded pumping rates have reached 30 gpm or more and the pumps have run continuously throughout the spring (Hupy, personal communication, 2003). Typical sump pump pumping rates are on the order of 3-5 gpm. It is likely this spring originally fed Thurston Pond and Millers Creek. It appears the discharge for many of these pumps currently outlets on the high side of the walking path around the pond. They should be re-directed to discharge on the low side (closest to the pond) of the path.
c) Take out the small concrete weir in the inlet pipes in Georgetown Boulevard. There is still a sump below the pipes to trap solids. Investigate the connection between the 48-inch storm drain in the street and the inlet connection and determine if taking more storm water from this pipe is feasible and/or required. We believe the additional re-direction of storm water and the sump pump discharge will help rejuvenate Thurston Pond.
d) A target water surface elevation for the pond should be set and the pond outlet structure revised. The target water surface elevation and revised structure characteristics should be based on a long-term hydrologic balance and the desired future ecological end point, e.g., wetland versus pond. The current outlet opening (inside the berm) should be significantly reduced and the overflow elevation lowered. The pond would overflow more frequently but the outflow rate would be very low. This provides more periods of low flow to Millers Creek and a higher turnover rate of pond water. The future habitat end point, weather extremes notwithstanding, would then be primarily a function of the proposed pond bottom elevation and the new overflow elevation.
e) Other activities recommended for the Thurston Pond area include tree plantings and Thurston School roof drain disconnects. The disconnected roof drains and school grounds yard drainage should be directed via open channel to Thurston Pond.
f) This project, in conjunction with other restoration efforts by the Thurston Pond Group, is a strong candidate for outside funding.

Focus Area #2

Ave Maria – Although this project is on private land, implementation of the proposed recommendations is a cost-effective opportunity. Some of these options should be explored with the new owner when the property changes hands (at the time of this writing, the property is for sale).

a) An opportunity exists to re-direct the storm sewer from Commonwealth to an outlet at the wetland complex in front of Ave Maria.
b) An extended detention structure could be built in front of the culvert that drains this wetland and discharges to Millers Creek. Modeling demonstrated smaller rain events can be detained and larger events passed without flooding existing structures. Approximately 150,000 CF of excavation would be necessary to maximize storage. The increase in wetland area due to the increase in flooded area could provide mitigation wetland opportunity for any area considered to be “lost” to high flood water levels in the lowest areas of the wetland. Wetland could be lost over areas where the water depths reach five or six feet periodically.
c) A Stormceptor or equivalent structural BMP should be used in the Ave Maria parking lot and at each of the properties along Commonwealth to catch solids and other pollutants before runoff reaches the wetland.
d) A large open, very gradual swale runs from north to south along the west side of the Ave Maria building. The hydrologic function of this swale could be enhanced by conversion to a bio-swale planted with native vegetation.
e) An excellent reforestation opportunity exists on the east side of this property.

Focus Area #3

Pfizer

a) If land is still available on the Pfizer property adjacent to the 1600 Huron Parkway campus after all required storm water management practices are in place, additional off-line floodplain storage along the east side of Millers Creek could be created. This off-line storage will help reduce the frequency of flooding on the east side of the creek (ponds B/B1) and reduce shear stress and peak velocities. The proposed design re-directs flows in the creek equal to and greater than the first flush event into a created riparian wetland. Inlet and outlet weirs control inflows, outflows and water level.
b) Some reforestation and natural area preservation is also recommended for this area.
c) In addition, some stream bank stabilization along this reach of the creek is necessary, but should be preceded by re-grading the creek to put some meander back into the channel.

Focus Area #4

Pfizer – Additional off-line floodplain storage along the east side of Millers Creek on the former ERIM property could be created if land is available after Pfizer has met its stormwater management obligations on this site. This flood plain storage will help reduce peak flows, water surface elevations, shear stress and peak velocities. The planning level design re-directs flows in the creek equal to and greater than the first flush event into a created riparian wetland. Inlet and outlet weirs would control inflows, outflows and water level.

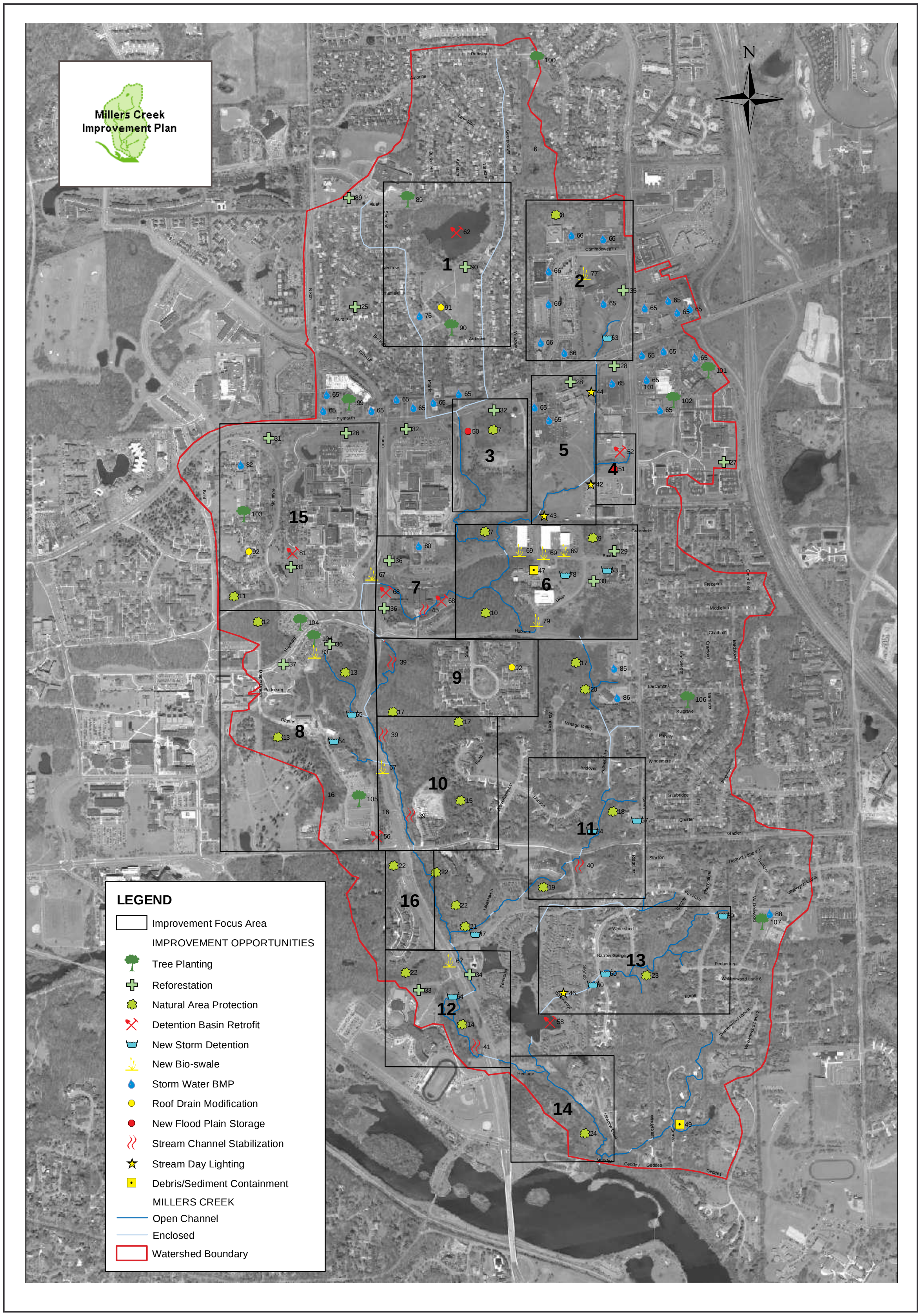

Figure 8.1 Improvement Opportunities and Focus Areas

Focus Area #5

<u>Pfizer</u> – An opportunity exists to daylight three existing culverts on the former ERIM property. This will improve stream habitat and aesthetics in this area. The culvert on UM's facility on Green Road could be daylighted as well.

Focus Area #6

<u>UM Along Baxter and Hubbard Woods</u>

a) There is a small ephemeral tributary to Millers Creek in Hubbard Woods that carries drainage from Hubbard to the creek. At the head of the tributary is an opportunity for a bio-swale planted with native vegetation.
b) The tributary is badly eroding in some spots and would benefit from bank stabilization and energy dissipation devices, such as the boulder drops recently installed at School Girls Glen in Nichols Arboretum.
c) The small pond just north of Hubbard and west of Green Road was apparently formed when a culvert under Hubbard was blocked. The culvert should be cleaned out and an extended detention outlet installed to reliably control outflows.
d) As much as possible, Hubbard Woods should be preserved. This is a hydrologically intact area covered with mature oaks and deserves preservation.

Focus Area #7

<u>University Of Michigan Hospitals and Health Centers North Campus Administration Complex (2901 Hubbard)</u>

a) The existing pond to the west of the administration building could be enlarged to provide off-line floodplain storage in the same manner as recommended above. This floodplain storage will help reduce peak flows, water surface elevations, shear stress and peak velocities. The proposed design re-directs flows in the creek equal to and greater than the first flush event into a created riparian wetland. Inlet and outlet weirs would control inflows, outflows and water level.
b) Another proposed floodplain storage wetland could be created on the west side of the 2901 Hubbard, just before the culvert under Huron Parkway. This flood plain storage will help reduce downstream peak flows, water surface elevations, shear stress and peak velocities. The planning level design and model implementation re-directs flows in the creek equal to and greater than the first flush event into a created riparian wetland. Inlet and outlet weirs would control inflows, outflows and water level.
c) There are opportunities in this reach for some low-intensity effort streambank stabilization. This would be a good area to focus volunteer effort.
d) There are also opportunities for native re-vegetation, including bio-swales to capture roof drain runoff.

Focus Area #8

UM Hayward Parking Lot and Grounds Facilities

a) The woodland just north of the lot should be preserved to the extent possible (See **Figure 8.2**).
b) A small detention wetland could be created on the south side of the lot to receive part of the runoff from the lot.
c) The outflow from this basin can still be directed to an existing ephemeral tributary to Millers Creek. However, this tributary is experiencing extreme downcutting and contributing solids downstream. Bank stabilization and energy dissipation, such as the boulder drops recently installed at School Girls Glen in Nichols Arboretum could be used to stabilize this area.
d) This tributary runs via a culvert underneath Huron Parkway to Millers Creek. An extended detention outlet could be installed at this culvert. This outlet structure will back up water into the existing wetland and during storm events create a backwater effect that will help slow some of the energy of the runoff coming from the Hayward Parking Lot.

Figure 8.2 Woodland North of the UM Hayward Parking Lot

e) A second ephemeral tributary runs south of the UM Grounds Facilities and is drained by a culvert that runs under Huron Parkway. This tributary is also experiencing downcutting and erosion. An extended detention outlet installed at this culvert would help back up water during storm events and reduce some of the energy of the runoff coming from the Hayward Parking Lot.
f) This ephemeral tributary could also be stabilized with energy dissipation devices, such as boulder drops, riprap and bank plantings.

Focus Area #9

Hubbard 84-inch Culvert Outlet – The recommendations detailed below will require a massive effort. Access will be difficult and the repairs and stabilization work will be expensive. At present, no infrastructure is under any immediate threat (See **Figure 8.3**). However, the retaining walls will likely fail completely over the next ten years, and significant amounts of sediment will continue to be lost downstream. Note, this reach has previously been identified as a Rosgen G-type stream. Based on the incised channel evolution model, the next phase in this reach is to build a floodplain within the incised channel. This channel within a

Figure 8.3 Hubbard 84-inch Culvert Outlet

channel will develop its own sinuosity and overbank vegetation and naturally reduce high flow shear stress. With a rebuilt floodplain inside the enlarged channel, high flows will be overbank flows again. In this reach, it is difficult to say how long it will take before the channel stabilizes itself without any outside effort. This is one of the most active geomorphic sites on Millers, and regardless of the type of efforts expended or not expended to improve its conditions, should be monitored regularly.

a) The force of the flows out of this outlet need to be better controlled. We recommend a series of massive boulder drop pools to dissipate energy from this culvert.
b) The retaining walls should be repaired.
c) The 18-inch culvert from Northwood IV needs to be stabilized. This culvert should also empty into a riprap stabilized pool.
d) While some bank stabilization is recommended in this area, cutting the flow energy will hasten the return to the sediment transport equilibrium this transitional area needs. Cutting the flow energy will decrease the flow's erosive power and likely enhance deposition in the area.
e) The stream valley in this area is fairly steep and covered by mature oak-hickory forest. The mature forest and steep slopes make this a good candidate for preservation.

Focus Area #10

<u>Baffle Box and Hubbard to Glazier Streambank Stabilization Areas</u>

The concrete support for the baffle box apron has voids, the downstream scour hole is relatively shallow, and the scour energy is still actively eroding the banks (See **Figure 8.4**). This reach has created some of the most serious threats to Huron Parkway and associated sidewalk. Despite some difficult access issues and high cost of stabilization work, some effort here is critical. Recommended bank stabilization efforts in this area are directed only at the banks closest to the Parkway. This stream channel reach is in a transitional state. The Rosgen stream types are F and G throughout the reach. This channel will eventually build a new floodplain within the incised channel. It is difficult to say how long this transition will take: the channel is still actively widening. It is also likely that the sediment trapped in the baffle box and later removed by the City of Ann Arbor is robbing the creek downstream of bed load. Bed loads help with the floodplain rebuilding work that should be taking place in this area. The recommended improvements in this area include:

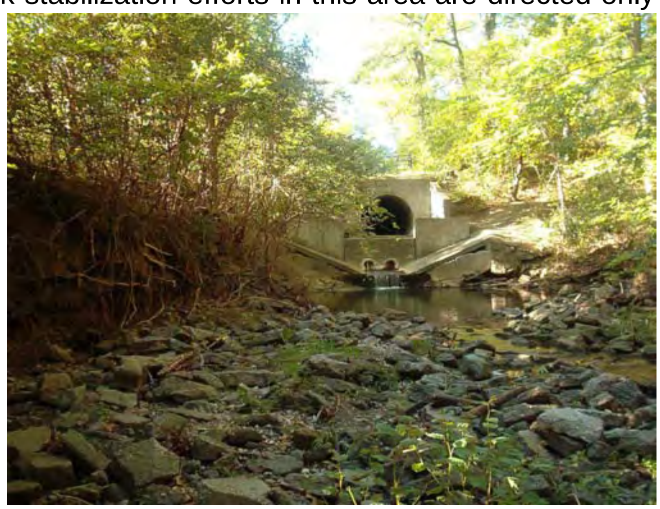

Figure 8.4 Baffle Box Structure Near Huron Parkway

a) The baffle box could be dismantled, and the energy blocks removed to feed sediment downstream in a more natural manner. The outlet will then need to be stabilized with a series of massive boulder drop pools. The boulder drop pools will reach their own equilibrium with the upstream sediment supply. The bank closest to the Parkway should also be stabilized with toe boulders, synthetic erosion control blanket and plantings.

b) There is another area of bank approximately 1000 feet downstream of this structure that should also be stabilized on the Parkway side. This location is the outside of a bend and is now approximately 11 feet away from the sidewalk. This location is actively eroding and likely to experience additional bank mass failure in the coming years. This area should be stabilized with toe boulders and planted, deformable banks. Deformable banks constructed of soil wrapped in synthetic geotextile are able to absorb high shear stress without simply redistributing flows downstream in the manner that hard armor solutions do (See **Figure 8.5**).

c) There is also some opportunity here for bank stabilization with a modest effort. In this reach a small mid-channel bar has formed and been vegetated. There is however, a small channel cut on the bank-side that has the potential to act as a high flow cut-off and bank de-stabilizing factor. This small channel should be filled with stone and dirt and vegetated with woody cuttings. This technique should help re-direct flows to the opposite bank and away from the Parkway.

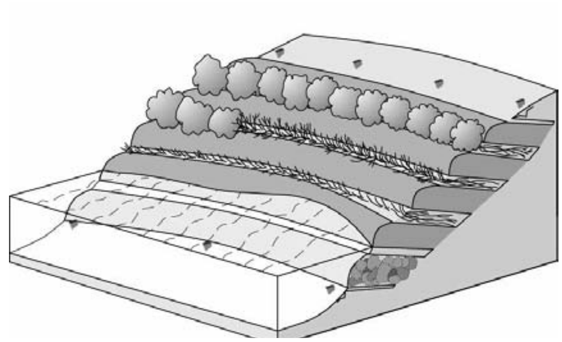

Figure 8.5 Vegetated Geogrid (deformable bank)

d) The toe of the slope along the bike pathway fence is eroding. Placement of log revetments and/or coir log with live plantings could be used to keep further erosion from peeling back the slope.

e) At the Glazier sampling site, there is an opportunity to stabilize the Parkway-side streambank with toe armor and planted deformable banks. The areas around the headwalls of the culvert running under Glazier also need to be filled, planted and stabilized to prevent further flanking.

f) Some of the stream valley in this area is also fairly steep and covered by mature oak-hickory forest. The mature forest and steep slopes make this area a good candidate for preservation.

Focus Area #11

<u>Lakehaven Tributary – Upper Reach</u>

There are some areas of significant bank erosion in this reach that could be stabilized. The installation of additional storm water detention in this area is also recommended. One possible area of detention is along the tributary itself. However, this area was not surveyed during this project and better topographic information would be required in this area before making a final determination on suitability of this option.

Focus Area # 12

<u>Huron High School Wetland Reach</u>

This improvement area is a critical location. As demonstrated earlier in the Existing Conditions chapter, with the active stream downcutting and channel widening from Hubbard to Glazier, significant amounts of stream bank and stream bed material in this reach are settling out in the Huron High School area. The highly mobile but extensive deposits at the High School, in the culvert under Huron Parkway and at the Huron High School sampling site corroborate this picture (**See Figure 8.6**). The culvert under the Parkway is nearly half-full. However, the deposits cannot simply be jetted out because these sediments are also the stream bed. Sediments could be captured at three possible locations upstream of the Huron Parkway culvert. This should help to “starve” the stream of sediment in this area. At a minimum, it should keep the culvert from filling in further. It is possible that this starving technique could naturally displace some of the sediment in the culvert and the reach downstream. The improvements in this area include:

a) Installation of a new baffle box at the inlet to the Huron High School channel reach. This structure will have a weir that directs low flows to the existing channel. High flows will be partially re-directed in the northwesterly direction up and through the existing wetland and some would continue to be directed down the main channel.
b) The wetland itself could be slightly re-contoured to effectively deal with the higher flows and sediment loads and enhanced with additional native plantings.
c) A downstream sediment trap could also be installed just above the culvert under Huron Parkway.

Figure 8.6 Sediment Deposition near the Huron High School Sampling Site

Focus Area #13

Geddes Lake Ponds

a) Two additional areas of new storm water detention are recommended for the lower reach of the stream tributary to the Geddes Lake ponds. In this area are two emergent wetlands, one upstream and one downstream of the Green Road crossing. Both wetlands are disturbed systems with extensive colonization by invasive species. The wetlands offer opportunity to create wetland detention for storm water storage and treatment.
b) Parking lot and roof drain wetland detention is recommended for the United Methodist Church on Green Road. The Methodist Church on Green Road near Glazier Way currently does not have any storm water detention. There is room on the south end of the parking lot to create detention. The parking lot and the roof drains could be routed to discharge to this detention basin.
c) Tree planting is recommended at the Windmere Road subdivision. The subdivision contains many open turf grass areas with low-density tree coverage.
d) This tributary eventually enters a culvert in the Geddes Lake community. This culvert could be “daylighted,” restoring open-channel hydraulics and macroinvertebrate habitat and creating an amenity out of the storm sewer.
e) Just off Narrow Gauge Way there is a mature oak forest that has been identified by the Natural Area Preservation (NAP) group of the Ann Arbor Parks and Recreation Department as a very high quality natural area. NAP and the NE Area Plan have identified this as a parcel worth preserving. This plan strongly concurs. A visit to the site is usually enough to establish the same conviction for many.

Focus Area #14

Ruthven Park

Ruthven Park is a wonderful recreational opportunity that almost no one knows about. This situation is representative of Millers Creek in general. Getting people to the park to experience its merits will first require improving access. The park also lacks a master plan. Improving access and signage will build more interest in the park. Future improvements could include trail enhancement and the design and installation of a boardwalk adjacent to the wetland complex. In fact, hydraulic modeling for this project found that entire wetland complex in Ruthven and immediately to the east of the park is within the Millers Creek/Huron River 100-year floodplain. This area of 100-year floodplain is effectively un-developable. **Figure 7.1** shows the recommended area for parkland acquisition (the area is shown as recreation and as Ann Arbor Township property immediately adjacent to Ruthven Park). The City should explore acquiring this land to expand Ruthven Park. Two alternative recommendations for improving access to Ruthven Park are:

- Alternative One: Acquire a public easement on the parcel to the immediate north of Ruthven Park (parcel ID: 01-26-200-028). This would make an excellent access area for the park and possibly enhance the value of any developments that might be built on that site.
- Alternative Two: Widen Geddes Road between Gallup Park and Ruthven Park and install a pedestrian island between the two lanes. Provide other traffic calming measures, including signage.

Focus Area #15

Pfizer Campus – 2800 Plymouth Road and UM's Northwood V Residential Housing

a) Additional reforestation opportunities exist both in Northwood V and on Pfizer's campus.
b) The directly-connected roof drains at Northwood V could be disconnected from the storm sewer and re-routed as overland flow to roof gardens or drywells (see **Figure 8.7** below).
c) The 48-inch storm sewer that runs under Pfizer's parking lot on 2800 Plymouth Road carries most of the runoff from Northwood V. Northwood V has no detention storage. Possible re-routing of storm water from Northwood V to Pfizer's storm water management system was investigated. However, re-routing storm water from the 48-inch line to existing Pfizer ponds does not appear feasible because the pipe appears to be too low. However, Pfizer staff have noted that pond 5B rarely holds water and thus may have intercepted a sand lens. Pfizer is investigating the possibility that this pond has a high infiltration capacity.

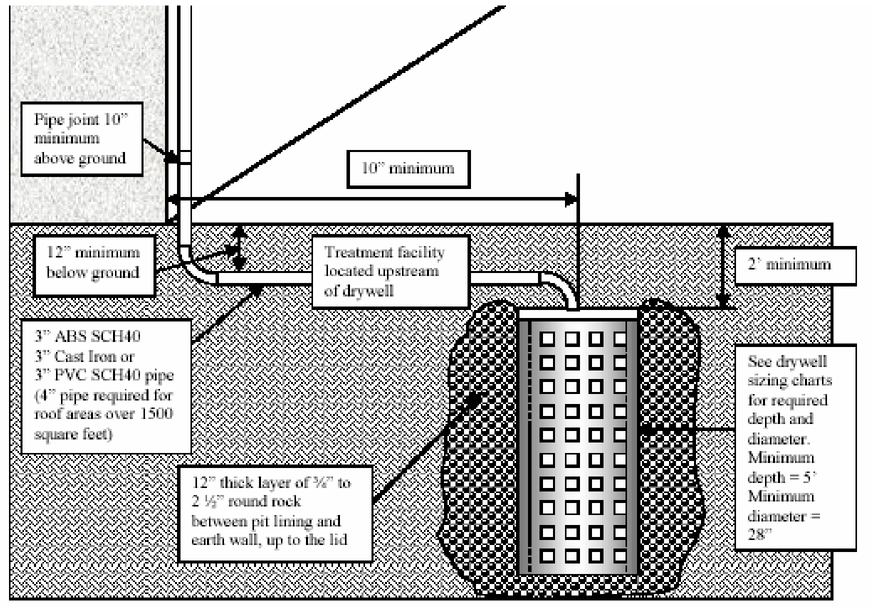

Figure 8.7 Example Drywell

Focus Area #16

Huron Parkway Median

Much of the Huron Parkway median is a thriving native prairie community. However, there are areas of turf grass and opportunities for utilizing more of the median for storm water management. Strategic curb cuts along the entire median could help capture Parkway runoff. A meandering low-flow channel with a shallow floodplain could be excavated in the median. Overflows could be directed to one of the many culverts that run under the Parkway. The two subareas identified with high infiltration capacities are Huron HS and Geddes. This idea would be particularly effective for application at the low end of the median near the High School. This work should be designed in close coordination with the NAP group in order to preserve the existing prairie communities they have worked so hard to create. Another possibility in conjunction with this work would be the installation of infiltration gutter pans along the outside curbs of the Parkway.

8.3.3 EXISTING MIDDLE HURON INITIATIVES AND TMDL IMPLEMENTATION ACTIVITIES

Several water quality improvement programs for the Huron River are already in progress. These programs are applicable because they address some of the water quality problems in the Millers Creek watershed, which is a source of phosphorus and *E. coli* to the Huron River. As such, the activities being implemented under those existing programs have been incorporated into the Millers Creek Improvement Plan. The two applicable programs are described below.

Middle Huron Initiative

The Middle Huron phosphorus TMDL was the first TMDL completed in the State of Michigan. The TMDL was completed and approved by EPA for Ford and Belleville Lakes in 1995, and it incorporates the Middle Huron River from Mill Creek to Belleville Dam, including Millers Creek and other tributaries. Phosphorus loading from Millers Creek must be reduced by 50% to meet the regulatory requirements of the Ford and Belleville Lake phosphorus TMDLs. Many of the Millers Creek improvement opportunities and project implementation alternatives have been designed to reduce phosphorus sources in the watershed.

To implement the TMDLs, the Middle Huron River Initiative was formed. This partnership of state agencies, local units of government, and institutions developed a phosphorus reduction strategy in 1996. The purpose of the partnership is to work together to voluntarily reduce phosphorus by 50% in the Middle Huron River and its tributaries. In general, the initiative involves:

- Improve modeling and monitoring of the basin to better identify sources of phosphorus;
- Support increased research and monitoring in the middle Huron;
- Support watershed education and planning efforts;
- Assist landowners and municipalities to develop and implement BMPs to reduce phosphorus, and other pollutants, to the watershed;
- Upgrade sewage treatment facilities;
- Provide for changes in the operation of wastewater treatment plants; and
- Provide a source of support to test innovative ideas to reduce phosphorus discharge to the middle Huron.

The Middle Huron Initiative, the partnership working to meet the nutrient TMDL, has pursued pollutant reductions for six years. Most of the stakeholders in the phosphorus TMDL are signatories to a five-year agreement to voluntary reduce phosphorus contributions to the middle Huron River, which will be re-evaluated in 2004 to determine whether significant progress has been made toward reducing phosphorus by 50 percent of 1996 levels. Some of the Initiative's partners have participated in MCAT and will continue to be involved in the implementation of the Millers Creek plan under the existing guise of the Middle Huron Initiative.

Geddes Lake, Huron River Pathogen (E. coli) TMDL
The Michigan Department of Environmental Quality (MDEQ) finalized the Geddes Pond/Huron River *E. coli* TMDL in August, 2001. The TMDL was approved by U.S. EPA on September 17, 2001. The listed segment addresses approximately five miles of the Huron River located in the Ann Arbor area, from Geddes Dam at Dixboro Road upstream to Argo Dam. This segment is also the receiving water for Millers Creek, among other tributaries (Allen Creek, Traver Creek, Malletts Creek, and Swift Run Creek). Previous water quality sampling in this area has shown that Michigan Water Quality Standards (WQS) for *Escherichia coli* (*E. coli*) are not consistently being met in the middle Huron River or its tributaries. Water quality sampling was conducted as part of the current Millers Creek Improvement Study. The results of that sampling confirmed that the *E. coli* WQS is being exceeded in Millers Creek (Refer to Chapter 5). All surface tributaries (not enclosed) are required to comply with the WQS of 130 *E. coli* per 100 ml as a monthly average. This requirement applies to Millers Creek, among others (Traver Creek, Malletts Creek, and Swift Run Creek).

Measures to reduce *E. coli* will include activities that, to a large extent, are already required of the National Pollutant Discharge Elimination System (NPDES) municipal storm water Phase I permittees within the watershed and other municipalities within the watershed under Phase II of the municipal storm water permitting program. Currently, the City of Ann Arbor, U-M and the Michigan Department of Transportation hold NPDES Phase I municipal storm water permits, while Ann Arbor Township has recently obtained a NPDES Phase II permit. Both Phase 1 and Phase II municipal storm water permits provide mechanisms for controlling bacterial loads to Geddes Pond and Millers Creek. Storm water permits require that a plan for effective elimination of illicit discharges and prohibition of illicit discharges be developed, that all catch basins be mapped and regularly cleaned, that effective storm water management in areas of redevelopment and new development occur, and that a public education program regarding storm water management and impacts of storm water pollution be implemented.

There are several specific actions being taken or planned by the regulated storm water communities to reduce *E. coli*. These actions pertain to, and will address, *E. coli* sources in the Millers Creek watershed. For specific information on these activities and there implementation, see the *E. coli* TMDL implementation plan in Appendices.

- Septic System Inspections (Ann Arbor Township, SE part of Millers Creek watershed)
- Illicit Discharge Elimination Plan
- Occupancy Permits, Disallow pending inspection for illicit connections
- Community Partners for Clean Streams
- RV Waste Disposal Education
- Storm Water Marking Project
- Information and Education Mass Media Campaign/Public Education Program (PEP)
- Information and Public Education Through the Internet
- Phase II public education and public involvement/Farmland Education (Agriculture)
- Education on Pet Waste
- Doggie Bags in Parks
- Pooper Scooper Ordinance
- Operation Goose Down
- Native Landscaping Ordinance Development
- *Update Storm Water Management Standards (Pond Landscaping Section)*
- Farmland Protection Program
- Comprehensive Plan
- Wetlands Protection Program
- Rules and Ordinances for Storm Water Management

8.4 MONITORING AND ADAPTIVE MANAGEMENT

The Millers Creek Improvement Plan is a working document that is intended to guide the improvement of Millers Creek and the Huron River. Due to the complexity of natural systems and urban landscapes, it is difficult to fully understand functional relationships between public administration, land use practices, weather, infrastructure, pollution sources, water quality, human behavior, hydrology, and other aspects of watershed management. It is expected that the implementation process will reveal new information, deeper understanding, and practical realities that can be used to improve the plan. An adaptive management approach is recommended for implementation of the Millers Creek Improvement Plan to facilitate the process of discovery, effective decision-making, and plan updates. Adaptive Management is the process of acting and then responding to the results of actions with informed decision-making. Adaptive management dictates, to varying degrees, the course and nature of future actions through a process of learning from previous actions.

An effective adaptive management program requires input from continuous monitoring to assess the effectiveness of implementation activities. The following monitoring activities are recommended to assess the effectiveness of the Millers Creek Improvement Plan. **Table 8.2** summarizes the recommended monitoring plan and proposed costs. The recommended monitoring activities have been selected to specifically measure the attainment of the plan's identified goals. As such, they are presented below in relation to the goal they are intended to assess.

1) **Watershed Land Use and Management**
The watershed land use and management goal has a stated objective that emphasizes stewardship through various resource protection and management activities. The qualitative nature of this objective calls for a qualitative monitoring approach that is consistent with typical Phase I and II storm water reporting. Monitoring watershed land use and management practices will be modeled after, and in some cases integrated with, the Middle Huron Initiative. Activities and related costs will be tracked and reported.

2) **Hydrology**
To meet the hydrology goals, the plan has a stated objective of reducing peak flows by approximately 50% for the bankfull storm event. We define the bankfull event at approximately the 1-year to 2-year design recurrence interval storm event. To assess the attainment of this objective, HRWC should maintain two transducers (at the Plymouth and Glazier sites) to collect continuous (10-minute intervals) flow data throughout the ten-year implementation schedule (years 1,4,5,9 and 10). HRWC should recreate the rating curves at a minimum of four of the flow study sites during the 10-year implementation period. HRWC should also repeat the geomorphology (channel shape) measurement once for each of the 5 study sites. Measuring the channel shape will allow HRWC to determine the areas and extent of bank erosion and channel adjustment. Collected rain data from either the Pfizer and/or the UM rain gage should be compiled annually as well.

3) **Water Quality**
The water quality goal of the plan has two stated objectives: decrease phosphorus loading by 50% from existing conditions and reduce *E. coli* numbers in surface waters to the state WQS of 130/100 ml (per Huron River phosphorus and *E. coli* TMDLs). Attainment of these regulatory requirements will be assessed by conducting periodic water quality sampling, but water quality improvements will take time to accrue. Water quality sampling should be conducted once every five years during the ten-year implementation schedule at the stations used during the Millers Creek study. Sampling shall be conducted between April 1 and November 1 during both wet and dry weather events to evaluate illicit connections and storm water related sources of phosphorus and *E. coli*.

4) **Fish and Wildlife Habitat**
The objective of the fish and wildlife goal is to improve the habitat and biological integrity of Millers Creek. To assess this objective, HRWC should continue to monitor three sites annually during the 10-year period. Monitoring will rotate between eight sites to allow the flexibility to monitor sites near where improvements are being made and to build on existing data, without monitoring every study site every year. In-steam habitat should be assessed between one and two times during the ten-year implementation schedule.

5) Public Understanding and Support

Public Involvement is a crucial step to support the plans to improve Millers Creek. By the time the Millers Creek study had been completed, a number of citizens in the watershed had become concerned and knowledgeable about the creek and its problems. The time is ripe to build upon this momentum and develop a focused effort to mobilize public support for protection and improvement of the creek. HRWC proposes to take a leadership role in this effort.

Table 8.2 Millers Creek Recommended Monitoring Plan and Costs

Item	Stations	Monitoring Frequency	Five Year Cost	Annual Cost	10 yr cost
Benthic Monitoring	8	3 sites/yr		$3,600	$36,000
Habitat Monitoring	8	4 sites in yrs 4,5,9,10	$7,500		$15,000
Rating Curve Adjustments	6	3 sites/3 yrs starting in 2005		$11,344	$34,000
Geomorphic Measurements	5	2 sites/4 yrs starting in 2006		$8,700	$17,400
Transducer Flow Data	2	2 sites in yrs 1,4,5,9,10		$10,000	$50, 000
Water Quality	5	Once every 5 yrs	$20,000		$40,000
Website	NA	NA		$3,500	$35,000
		Annual Total		Total 10 year Cost	$227,400

8.5 Funding Sources

Table 8.3 provides a list of available funding sources that are applicable to the Millers Creek Improvement Plan. One potential source of funding not included in the list is the assessment of drainage districts. This source of funding would become applicable if all or parts of Millers Creek were designated as a County Drain. However, due to the high costs associated with improving Millers Creek, grant funding will be necessary to control local costs. Once the Millers Creek Improvement Plan has been incorporated into the Huron River plan and the MDEQ has approved the update, Millers Creek will be eligible for many types of non-point source grants, including Clean Michigan Initiative grants. The most appropriate source of funding will be determined by the nature of each individual project or action. The diversity of actions recommended for Millers Creek will require a diversity of funding sources. **Table 8.3** presents information on grants for habitat improvement projects, recreational improvements, capital improvement projects (e.g., storm water infrastructure), and public outreach programs.

Table 8.3 Potential Grant or Loan Sources for Millers Creek Improvements

Grant Information	Grant or Loan Program				
	319 Targeted NPS Control Efforts	CMI Volunteer Monitoring	CMI Local Water Quality Monitoring	CMI Illicit Storm Sewer Connections	319 NPS Watershed Implementation Projects
RFP Due Date	January	Varies Year-to-year 60 days following advertisement	TBD	December	August
Required Match	25%	25%	25%	25%	25%
Maximum Grant Amount	None	$10,000	$50,000	Varies year-to-year	
Maximum Duration of Project					
Type of Project	Implement physical improvements for TMDL waterbodies	Collect water quality data, generate local interest, promote volunteerism			Implementing non-physical elements of approved plans
Qualified Applicants	LUGs, non-profits *(qualifying watershed plan required)*	Non-profits, volunteer orgs.,LUGs		LUGs, non-profits	LUGs
Contact Information	Amy Peterson SWQD	Gary Kohlhepp SWQD		Mark Fife SWQD	
Telephone Number & E-Mail	(517) 373-2037	(517) 241-9534		(517) 241-8993	

Grant Information	Grant or Loan Program				
	Great Lakes Aquatic Habitat Fund	CMI Local Parks & Recreation	Community Foundation for Southeast Michigan	Community Foundation for Southeast Michigan	MDNR Non-Game Wildlife Grants
RFP Due Date	March 31 & September 30	April 1 & September 1 *(must have MDNR approved plan)*	June 1 & December 1	June 1 & December 1	December 1
Required Match		25%	60%	0% *(encouraged)*	0%
Maximum Grant Amount	$3,500	$750,000	$1,000,000	$100,000	$5,000
Maximum Duration of Project		2 years	2 years	1 year	
Type of Project	Empower local citizens to improve & protect water resources	Recreation infrastructure & community recreation facilities	Land grants for greenway implementation	Greenway development – planning, design, permitting, etc.	Restoration & promotion of native species and natural communities
Qualified Applicants	Non-profits, grass roots organizations	State, LUGs	LUGs, non-profits	LUGs, non-profits	Individuals, LUGs, non-profits
Contact Information		Deborah Apostol	Tom Woiwode	Tom Woiwode	Lori Sargent
Telephone Number & E-Mail		(517) 335-6871 apostold@state.mi.us	(313) 961-6675 twoiwode@cfsem.org	(313) 961-6675 twoiwode@cfsem.org	(517) 373-9125

Grant Information	Grant or Loan Program				
	Strategic Water Quality Initiatives Fund	U.S. EPA NPS Water Pollution Control	Michigan River Network	Great Lakes Basin Program for SESC Control	NFWF 5-Star Restoration Challenge Grants
RFP Due Date	July 1 *(plan approval required)*	Variable	May	January	June 1 & October 15
Required Match		40% *(non-federal)*	25%	25%	None
Maximum Grant Amount	Loan Program	Variable		$100,000 *(large scale)* $30,000 *(small scale)*	$10,000
Maximum Duration of Project					1 year
Type of Project	On-site septic systems, remove ground water or storm water from sanitary sewers	BMP implementation including enhancement of aquatic & riparian habitats	Volunteer cleanup projects, particularly trash & debris removal	BMPs for reducing soil erosion and sedimentation, including stream restoration	Collaborative wetland & riparian enhancement with education & outreach
Qualified Applicants	LUGs *(strict eligibility and compliance req.)*	LUGs, State, non-profit	LUGs, non-profits	LUGs, non-profits	Any public or private entity
Contact Information	Dave Krusik	Kevin Pierard	Michigan River Network	Gary Overmier	Tom Kelsch
Telephone Number & E-Mail	(517) 373-4727	(312) 886-4448	(231) 347-1181	(734) 971-9135	kelsch@nfwf.org

Grant Information	Grant or Loan Program				
	State Revolving Fund	DTE Energy Tree Planting Grants	NFWF Pulling Together Initiative	EPA Environmental Education Grants	MDNR Community Tree Planting
RFP Due Date	June 1 Complete project plan required	November 29	Open	January 6	October 1
Required Match	Low Interest Loan with 20-year payoff	25%	100% In-kind acceptable Competitive	25%	None
Maximum Grant Amount	Loan Program	$4,000	$100,000	$25,000	Number of trees unlimited, but not guaranteed
Maximum Duration of Project	Based on projected 20-year needs	1 year	3 years or up to 5 years under some circumstances	1 year, 2 years for larger budgets	Monitoring and reporting required for 2 years
Type of Project	Storm water treatment, non-point source control facilities	Plant trees on public lands or land open to the public	Public/private partnership formation to control invasive plants	Environmental education activities	Community tree planting (seedlings)
Qualified Applicants	LUGs *(strict eligibility and compliance req.)*	Non-profits, schools, LUGs	Non-profits, schools, LUGs	Schools, non-profits	Trees must be planted on public lands
Contact Information	Dave Krusik	DTE: Roberta Urbani MDNR: Kevin Sayers	Jacqueline Altieri	Diane Berger	Ada Takacs
Telephone Number & E-Mail	(517) 373-4727	(313) 235-8624 urbanir@dteenergy.com (517) 241-4632 sayersk@michigan.gov	(202) 857-0166 jackie.altieri@nfwf.org	(202) 260-8619 berger.diane@epa.gov	(989) 275-5151

Grant Information	Grant or Loan Program				
	Ann Arbor Area Community Foundation	NFWF General Matching	NOAA	Plant Conservation Alliance	Watershed Assistance Grant
RFP Due Date	October 1 Must seek approval prior to submittal	Pre-Proposal 6/1 & 10/15 Full-Proposal 7/15 & 12/1	Posted on NOAA Home Page	12/03 & 7/04	Federal Appropriations For '04 not approved yet
Required Match		2:1	1:1		
Maximum Grant Amount			$150,000 Average $40,000	$5,000-$40,000	$1,500-$30,000
Maximum Duration of Project					18-months
Type of Project	Education, community development, environmental awareness	Conservation, Habitat Study, Community Development	Education, Outreach, Fisheries, Invasive Species Study, Wetland, Non-Point Source	Native Plant Communities	Solutions to problems; budget less than $200,000
Qualified Applicants	Open	Non-Federal, Voluntary	Business, Watershed Council, Education, Conservation, Local & State Government	Open	Local Watershed Councils, Non-Profit
Contact Information	Martha Bloom			PCA Website	
Telephone Number & E-Mail	(734) 663-2173		(301) 713-0174 Alison.ward@noaa.gov		wag@rivernetwork.org

Table 7.1 Costs and Proposed Implementation Schedule for Recommended Improvement Opportunities

Focus Area	Priority	Activity	Respons-ibility	Schedule (Year)										Costs ($)
				1	2	3	4	5	6	7	8	9	10	
	1	Create Millers Creek Drainage District	WCDC	X	X									$200,000
	1	Middle Huron River phosphorus reduction strategy	Various	X	X	X	X	X	X	X	X	X	X	$0
	1	Middle Huron River Illicit Discharge Elimination Program	WCDC	X	X	X	X	X						$150,000
	1	Millers Creek Public Involvement Program	HRWC	X	X	X	X	X	X	X	X	X	X	$209,000
	2	Ann Arbor Township septic system inspection program	AAT	X	X	X	X	X	X	X	X	X	X	$50,000
	2	Storm drain labeling	HRWC	X		X		X		X		X		$15,000
	1	Tree planting	Various	X	X	X	X	X						$52,000
	2	Reforestation	Various		X		X		X		X		X	$334,559
	2	Turf grass reduction/Native Plant conversion campaign	HRWC	X	X	X	X	X						$12,000
	1	Residential roof drain disconnect	AA/AAT	X	X	X	X	X						$250,000
	1	Implement fertilizer ordinance/policy	AA	X	X									$0
	1	Natural area preservation strategies	AA/UM		X	X	X	X	X	X	X	X	X	$400,000
	3	Improve SESC inspection and enforcement capabilities	AA		X	X	X	X	X	X	X	X	X	$214,286
	3	Native vegetation management (invasive plant control)	AA			X		X		X		X		$40,000
9,15	2	UM Northwood IV & V roof drain modification	UM		X	X								$262,340
1	2	Thurston Elementary School roof drain modification	AAS		X									$20,000
	1	Monitoring/Web Site Updates	Various	X	X	X	X	X	X	X	X	X	X	$227,400
	-	Geddes Pond detention retrofit	-	Completed										NA
	-	Retention basin UM Grounds maintenance facility	-	Completed										NA
	1	Street sweeping	AA		X	X	X	X	X	X	X	X	X	$250,000
7,8,10,16	3	Huron Parkway median bio-swales	AA		X	X								$838,500
1	1	Thurston Pond stormwater detention retrofit	AAS		X	X	X							$52,000
8	1	UM Orange Lot (NC51) detention basin retrofit	UM			X	X							$19,500
7	2	UM Administration Building detention basin retrofits	UM				X	X						$606,300
4	3	Pfizer/Veridian building (Green Road) detention retrofit	Pfizer				X	X						$415,607
	3	Proprietary in-ground BMPs	Private/ Various			X	X	X	X	X	X	X	X	$1,281,675
	3	Demonstration Rain Gardens	AA			X	X	X	X	X				$50,000

Focus Area	Priority	Activity	Respons-ibility	Schedule (Year)										Costs ($)
				1	2	3	4	5	6	7	8	9	10	
2	3	Ave Maria wetland detention creation	WCDC?				X	X	X					$1,592,757
3	2	Pfizer PUD floodplain storm water detention creation	Pfizer					X	X					$1,941,365
12	1	Huron High School detention/sediment trap creation	AAS/ WCDC?			X	X							$422,500
4	3	Pfizer PUD Green Road floodplain detention (2 facilities)	Pfizer			X	X							$1,775,431
11	3	United Methodist Church Parking lot and roof drain detention creation	Private				X							$93,984
11	3	Green Road detention upstream of Geddes Pond	WCDC				X	X						$260,000
8	3	UM Yellow Lots (NC53) detention creation at Huron Parkway	UM				X	X						$15,000
6	3	Michigan League/Dean Road detention creation	Private						X	X				$799,500
13	3	Earhart Park detention creation	Private/ WCDC						X	X				$300,000
	1	Storm water infrastructure repairs	WCDC		X	X	X	X	X					$257,000
9,10	1	Priority streambank stabilization	WCDC		X	X	X	X	X					$1,650,000
9,10	3	Priority bed stabilization	WCDC					X	X	X				$1,405,000
9,10	3	Priority in-stream habitat improvements	WCDC					X	X	X				$100,000
6,8,11	3	Non priority channel stabilization and habitat improvements	WCDC								X	X	X	$245,000
1	1	Clague Middle School - storm sewer disconnect	AAS		X									$20,000
2	2	Ave Maria Bio-swale	Private/ WCDC				X							$283,140
6	2	Bioswale/UM Plant Services Storm Sewer Disconnect	UM			X								$104,000
5,13	3	Stream Daylighting	WCDC								X	X	X	$540,000
14	2	Ruthven Nature Area Access	AAPR			X								$40,000
				$487,210	$262,600	$2,694,622	$3,675,173	$3,448,044	$3,015,114	$2,070,968	$1,838,397	$943,858	$891,752	
				ANNUAL PROJECT COSTS										

Notes:

1 = First priority - Item is either on-going, low effort/high return or critical
2 = Second priority - Item is medium effort or short to mid-term need
3 = Third priority - Item is high effort or long-term need.

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